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ABSTRACT

This guidebook sets forth five different methods for analyzing curricula. It is designed to be used primarily by teachers, curriculum supervisors, and administrators but may also be used by parents, students, and community members as they select materials for use in the classroom. The analytic methods are: (1) TIMSS Curriculum and Textbook Analysis; (2) National Science Foundation (NSF) Instructional Materials and Review Process; (3) American Association for the Advancement of Science's (AAAS) Project 2061 Curriculum-Analysis Procedure; (4) California Department of Education Instructional Resources Evaluation; and (5) Council of Chief State School Officers (CCSSO) State Curriculum Frameworks and Standards Map. These five methods were selected for this guidebook because each reflects a unique framework and/or set of standards. The selected methods vary in their depth of analysis, the time and resources necessary for implementation, potential uses, and the types of information and conclusions that can be obtained from each. All methods also focus on how instructional materials address the needs of diverse learners, including students with disabilities and second-language learners. (AIM)

ATTAINING
EXCELLENCE

TIMSS as a Starting Point to Examine Curricula

Guidebook to Examine School Curricula

U.S. Department of Education
Office of Educational Research and Improvement

ATTAINING EXCELLENCE

TIMSS AS A STARTING POINT TO EXAMINE CURRICULA

GUIDEBOOK TO EXAMINE SCHOOL CURRICULA

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The *Guidebook to Examine School Curricula* is based on years of effort at the national, state, and local levels. The groundbreaking work done by the National Science Foundation to create high-quality mathematics and science materials, along with the efforts of hundreds of teachers to test not only those materials but also ways to evaluate the material, form the core of this module.

We relied on the work of the Expert Panel on Mathematics and Science Education sponsored by our colleagues in the Office of Reform Assistance and Dissemination to provide a first look at curriculum analysis methodologies linked to standards and frameworks. Their work in identifying analysis methods linked to standards and frameworks made this module possible.

The members of the working team for this module were Janice Earle of the National Science Foundation, Jo Ellen Roseman of the American Association for the Advancement of Science, Barbara Kapinus and Rolf Blank of the Council of Chief State School Officers, and Patricia O'Connell Ross and Margaret E. McNeely of the Office of Educational Research and Improvement. Lois Peak and Eugene Owen of the National Center for Education Statistics guided our efforts to look closely and accurately at the TIMSS findings. Cynthia Hearn Dorfman and colleagues in Media and Information Services guided the production of the *Guidebook*. Rima Azzam and staff at the Pelavin Research Institute and the Education Statistics Services Institute, Ruth Chacon and staff at The Widmeyer-Baker Group, and Axis Communications managed the editing and design of this *Guidebook*. All contributed their valuable time and effort, beyond their already burdened schedules, to make this module better and more useful.

Contents

Overview of Curriculum Analysis

Of the many lessons we can learn from the Third International Mathematics and Science Study (TIMSS), one of the most compelling is the variation in what is taught to and expected of students. Mathematics and science curriculum standards, frameworks, and instructional materials are quite different in the countries participating in TIMSS. The conventional wisdom holds that mathematics and science are subjects without national boundaries. However, TIMSS shows the differences in how mathematics is taught and the disparities in expectations for students.

The TIMSS curriculum study, which is discussed in greater detail later in this *Guidebook*, analyzed the scope and sequence of mathematics and science frameworks, standards, and textbooks at every grade level tested in the participating countries. The variation is startling, especially at the middle to high school years. In addition to the international perspective, an in-depth analysis was done for the United States. The report on the United States, titled *A Splintered Vision: An Investigation of U.S. Science and Mathematics Education* and summarized at the end of this volume, states, "[S]plintered visions produce unfocused curricula and textbooks that fail to define clearly what is intended to be taught." (Schmidt 1996)

The relationship between curriculum offerings and student achievement will be studied as more of the TIMSS data are released. The comparisons that can be made now among the findings of the curriculum study, the teacher questionnaires, the teacher video study, and the achievement tests lead to the following insights about the curricula offered to our nation's students:

- The content of U.S. eighth-grade mathematics classes is not as challenging as that of other countries.
- Topic coverage is not as focused in U.S. eighth-grade mathematics classes as in the classrooms of other countries. (National Center for Education Statistics 1996)

While the TIMSS studies do not yet draw a conclusive link between curriculum and achievement, they reinforce what researchers, policymakers, and teachers have long believed about the variable quality and lack of coherence in U.S. mathematics and science curricula.

ANALYZING FRAMEWORKS AND TEXTBOOKS

How decisions are made to purchase materials and the criteria used to select one set over another have a major impact on what students are expected to learn and what teachers teach over many years. While some school districts may use a thoughtful approach to match curricular aims and goals to instructional materials and textbook series, far too many have neither the resources nor the time to make deliberative decisions. The selection of a textbook, or any kind of instructional material, needs to be based on a clear set of instructional principles and learning goals. Without an in-depth analytic review, there is no way of knowing whether the material will actually help students learn what is expected.

In school year 1993-1994, almost $5.5 billion was spent on instructional materials by public schools in the United States. The decisions on what to purchase were probably made by curriculum committees comprising teachers, administrators, central office personnel, and community members. In some states, selections were made from a list of materials approved by a state-level agency or commission. Most states, however, leave these decisions to local decision-making bodies who select from the broad marketplace.

We know from TIMSS and other research the importance of aligning all aspects of the education process to ensure that students are provided with the best opportunities to achieve to high standards and meet high expectations. The interactions among instructional materials, pedagogy, assessment, teacher preparation, school capacity, and expectations determine what and how much students learn.

A school's curriculum is made up of many different parts. It includes textbooks, workbooks, independent assignments, teacher-developed materials, and state and district frameworks. The most common and recognizable piece, however, is the textbook. While there is much debate over how much control textbooks have over instruction, we do know that they focus the instructional scope and sequence for most teachers and students.

Most school districts also have curriculum guides or frameworks that articulate expectations for what is taught. Recently, many districts also have developed standards aligned with state standards or modeled after those developed by professional organizations and groups, such as the National Council of Teachers of Mathematics, the American Association for the Advancement of Science's Project 2061, and the National Research Council's

National Science Education Standards (NSES). These documents add another level of expectations, yet textbooks and other instructional materials are rarely aligned with them.

Given the variety of documents, each articulating its own view of mathematics and science curricula, a systematic approach to analysis becomes even more important.

Using the Guidebook

This *Guidebook* sets forth five different methods of analyzing curricula. It is designed to be used primarily by teachers, curriculum supervisors, and administrators, and may also be used by parents, students, and community members as they select materials to use in classrooms. The analytic methods are as follows:

- TIMSS Curriculum and Textbook Analysis,
- National Science Foundation (NSF) Instructional Materials and Review Process,
- American Association for the Advancement of Science's (AAAS) Project 2061 Curriculum-Analysis Procedure,
- California Department of Education Instructional Resources Evaluation, and
- Council of Chief State School Officers (CCSSO) State Curriculum Frameworks and Standards Map.

These five methods were selected for inclusion in the *Guidebook* because each of them is tied to a framework and/or set of standards. This alignment was an important criterion for inclusion in the *Guidebook.* The methods selected vary in their depth of analysis, the time and resources necessary, their potential uses, and the type of information and conclusions that can be gleaned from each. All of the methods pay particular attention to how instructional materials address the needs of diverse learners, including students with disabilities and second-language learners.

Selecting a Method of Analysis

The section **Guide to Using the Methods of Analysis** includes more information on suggested ways of using each method and brief profiles that will help you select the most appropriate method(s) for your purposes. The following questions may help you evaluate each of the analytic methods:

- Will the results of this analysis be used to select new instructional materials or assessments, evaluate the scope and sequence of current materials, and/or determine the alignment between state frameworks and instructional materials?
- Will the evaluation be done by teachers or broad-based community groups?
- Will the results be used by curriculum committees, members of the public, and/or administrators?

It needs to be noted that this *Guidebook* does not examine the role of teachers and the efficacy of different instructional practices. While most of the methods of analysis do include pedagogy and ease of use as aspects to be examined, the focus is not on teaching per se. The capacity of the school system, including teachers' instructional approaches and professional preparation, influences how instructional materials come alive in the classroom.

Regardless of which analytic methods are used, every school or district needs to ask itself what students are expected to know, when they are expected to know it, and what materials are used. The TIMSS results have shown that U.S. curricula are generally not as rigorous as those in Germany and Japan. All eighth graders in these countries spend most of the year studying algebra and geometry, while most U.S. students study these subjects later. Only by looking deeply and systematically at what is expected and taught will we be able to raise student achievement.

Reviewing curricula as a whole needs to be part of every school's decision-making portfolio. These procedures inform important decisions that are made regularly in schools throughout the country.

Guide to Using the Methods of Analysis

Purpose

The purpose of this *Guidebook* is to present different ways of analyzing instructional materials for mathematics and science, including curricula, curriculum frameworks, textbooks, instructional modules, classroom activities, or teachers' guides. Each of these methods of analysis provides different sets of information about instructional materials, ranging from descriptions and analyses of content and structure, to evaluations of their potential for leading to specific learning goals. Thus, whether you are designing, reviewing, or selecting materials, some components of this module are relevant.

Uses of the Analysis Methods

As you develop, review, or select your instructional materials, there are several ways you might use these different methods:

- **As a general reference**—Each of these methods emphasizes certain qualities, such as balance of topics, student skills and behaviors encouraged, or connection to specific curriculum frameworks. These qualities should be kept in mind as you conduct your own curriculum development and review processes.
- **Adapted to local needs**—These methods have two components, a methodology (process of analyzing curriculum materials) and a frame of reference (frameworks or standards to which they are compared). Even if you have a different frame of reference (such as your own state's curriculum framework), you will be able to adapt the methodology to your own needs.
- **As presented**—If the frame of reference is relevant to your needs, you may wish to use a particular method as presented. In some cases, the material included in this *Guidebook* is sufficient for you to conduct the analysis yourself, while in other cases you may need additional resources or assistance from an outside organization.

The methods of analysis in this *Guidebook* examine instructional materials before they are put into use by schools and teachers. They examine the content and quality of the materials as a set of documents that articulate a course of study and an instructional approach. In fact, the primary goal of one of the methods, the AAAS Project 2061 Curriculum-Analysis Procedure, is to judge the materials in terms of the likelihood that they would contribute to the attainment of specific learning goals. If questions of implementation and impact are also among your concerns, you should consider additional, more direct methods of assessing these factors.

As you decide which methods to use, you must be sure that they are appropriate to your needs. Individual methods examine particular aspects of instructional materials. For example, the TIMSS Curriculum and Textbook Analysis looks at the topics to be presented but does not examine the accuracy of the material. The CCSSO Curriculum Frameworks and Standards Map looks at broad frameworks and standards but not at instructional materials.

Each of the analytic models should be reviewed carefully before any decisions are made to use one instead of another. Each reflects a different perspective on curriculum materials, requires different amounts of time to complete, and may require training or additional assistance.

Guide to Contents

This section provides a matrix of the five analytic methods presented in this *Guidebook* and a brief description of each. The brief descriptions answer key questions about each method and should be used as an overview and to compare the methods.

The section **TIMSS Curriculum and Textbook Analysis** includes a background and overview of the process and how it was used.

The **Other Curriculum-Analysis Methods** section presents four additional methods of analysis for examining instructional materials:

NSF Review of Instructional Materials—Developed by the National Science Foundation to review its funded comprehensive middle-school science and mathematics projects.

AAAS Project 2061 Curriculum-Analysis Procedure—Developed by Project 2061 at the American Association for the Advancement of Science for reviewing a variety of prepared curriculum materials.

California Instructional Resources Evaluation—Developed by the California Department of Education for its Instructional Resources Adoption Process.

CCSSO Curriculum Frameworks and Standards Analysis—Developed by the Council of Chief State School Officers to describe state mathematics and science standards and curriculum frameworks.

For each method of analysis, the *Guidebook* contains background information, a description of the analysis process, and, in some cases, forms or other instruments for conducting the analysis. There is also an overview for each method of analysis that summarizes it in terms of several key questions. The methods of analysis are outlined in the matrix that follows on page 9.

KEY MATRIX AND OVERVIEW HEADINGS INCLUDE:

- **What issues does it address?** Not all of the methods look at the same issues or answer the same questions. Some of the methods review only content and seek to answer fairly focused questions, such as "Which curriculum topics are addressed, and how much attention is devoted to each?" Others are more in depth, looking at issues of pedagogical approach and answering such questions as "Is this material acceptable for use?"
- **What materials does it examine?** Some methods are designed to look only at topics and subtopics to be addressed. Others look at textbooks and teachers' guides, which, in addition to an outline of topics, provide student activities and instructional strategies. Some are designed to look at any of these individually or as sets.
- **What is the frame of reference?** All methods involve comparisons to a particular framework or set of standards for mathematics and science, such as a state framework or the National Council of Teachers of Mathematics' (NCTM) *Curriculum and Evaluation Standards for School Mathematics*, the *National Science Education Standards (NSES)*, or the *Benchmarks for Science Literacy* from the AAAS Project 2061. Although you may base your curriculum on another framework, the method of analysis will still prove useful.

- **What is the analysis process?** Most methods involve the use of review forms or protocols. The processes differ, however, in the level of detail at which materials must be examined and whether they require teams of reviewers.
- **What resources does this type of analysis require?** The process of materials analysis may be a major undertaking, requiring large amounts of staff time and special funds. In some cases, the people performing the analysis should possess particular backgrounds, such as in teaching science, or familiarity with a particular framework. Also, using a specific method may require the purchase of additional resources, such as training materials, guidebooks, or evaluation forms.
- **Does this analysis require outside assistance or special training?** To use some of the methods, it may be necessary to send materials to an outside organization for analysis or to consult with the developers. In some cases, special training for using the method is available.
- **What are the potential uses at the local level?** Each of the methods will provide different types of information and assist the user in drawing different types of conclusions.
- **Contact information.** The people listed are available to answer more detailed questions about the methods and about using them in your school or district.

Overview of Methods of Analysis

	TIMSS Curriculum and Textbook Analysis	NSF Instructional Materials Review Process	AAAS Project 2061	California Instructional Resources Evaluation	CCSSO Frameworks Map
Issues Addressed	Topics covered, total number of topics, sequencing, comparison to international benchmarks, performance expectations	Alignment with *National Science Education Standards (NSES)* and NCTM standards, content quality, pedagogical design, assessment methods, support for implementation, equity	Alignment of content coverage with *Benchmarks for Science Literacy*, *NSES*, NCTM standards, or similar learning goals; effectiveness of instructional strategies aimed at learning goals	Content, organization and structure, work required of students, attention to student diversity, integration of assessment and instruction, support for teachers	Development of standards, content, pedagogy, materials, and assessment policies
Materials Examined	Curriculum guides, textbooks	Sets of instructional materials (e.g., teachers' guides, student books, multimedia material)	Instructional materials, including textbooks and teachers' guides	Textbooks, other instructional resources	Curriculum frameworks, content standards
Frame of Reference	TIMSS Curriculum Frameworks, profiles of other countries	*NSES* and NCTM standards	*Benchmarks for Science Literacy*; national standards in science, mathematics, and technology	California State Frameworks	Set of elements developed by CCSSO expert panel
Process	Classify each topic and subtopic, analyze distribution	Review teams rate using specified criteria and forms	Review teams evaluate using specified learning goals and sets of criteria	Review teams rate using specified criteria and forms	Categorize and codify
Resources Needed	Fee determined by extent of analysis	Five working days for each team member (4-5 people per team)	At least 2 people per material, 3 to 5 days of training, several days per unit, various materials (see Project 2061 section)	Five working days for each team member (4 to 5 people per team)	Two staff members per document
Outside Assistance	Analysis conducted by U.S. TIMSS staff	Available through NSF	Customized training programs available through Project 2061	Consultation with framework experts recommended	Available through CCSSO

Overview of TIMSS Curriculum and Textbook Analysis

Background

The TIMSS project provides a comprehensive look at mathematics and science education in different countries. It focuses on three areas: intended curricula (what is supposed to be taught), implemented curricula (what is actually taught and how), and achieved curricula (what is learned). The curriculum and textbook analysis process presented in this module was designed to address the first and second areas, intended curricula and implemented curricula. TIMSS researchers used this process to compare curriculum documents across almost 50 countries. Prior to TIMSS, international comparisons of curricula relied primarily on the opinions of experts. The TIMSS curriculum and textbook analysis provides a systematic method of analyzing and comparing original curriculum documents using an international framework. It should be emphasized that it is an analytic tool, meaning that it does not make judgments regarding what is good or bad, but rather seeks to illustrate the similarities and differences between mathematics and science curricula in different countries.

What issues does it address?

Breadth and depth of content (topics, e.g., relationships of common decimal fractions) and performance expectations (thinking skills, e.g., formulating and clarifying problems and situations). Within a grade, it can help you determine whether you are covering many topics, but with brief attention to each, or if your curriculum is more focused, and whether the performance expectations are balanced. You can also see how the sets of topics and performance expectations change from grade to grade. You can compare your curriculum "profile" to those of schools in other countries.

What materials does it examine?

Curriculum guides and textbooks.

What is the frame of reference?

The TIMSS Curriculum Framework and curriculum profiles of other countries.

What is the analysis process?

Items in the materials to be examined are placed into frameworks of categories and subcategories of content topics and performance expectations. The results are then analyzed to show which topics and performance expectations are addressed, under which broad areas they fall, the amount of time devoted to each, and the total number of topics and performance expectations.

What are the potential uses at the local level?

Although the analysis methods presented here were developed to compare curricula across countries, they have several potential uses for local schools and districts, for example:

- **Benchmarking to a country involved in the TIMSS study, a group of countries, or an international composite.** This is useful to schools, districts, and communities interested in knowing how their curricula compare with those of a country, or set of countries, with high levels of student mathematics and science achievement, or with countries they see as having high standards.
- **Comparisons of topic coverage profiles with local goals and priorities.** While the TIMSS analysis did not make judgments about whether a curriculum was good or bad, these may be the types of judgments schools and districts would like to make. With a TIMSS-style profile of topic coverage and performance expectations, schools and districts can determine where there are undesirable gaps/overlaps in their science and mathematics curricula across grade levels. The results would help them see if they have too many topics at a given grade level and if they are not giving enough attention to a particular topic.
- **Substitution of another framework for the TIMSS framework.** Schools and districts may use similar methods of Topic Trace Mapping and Document Analysis, but with a different curriculum framework, such as a state framework or the *NSES* or NCTM standards. Only when the TIMSS framework is used, however, can districts compare themselves to other countries or international benchmarks.

Does this analysis require outside assistance or special training?

Performing this analysis as was done for the TIMSS project requires the assistance of the TIMSS staff at Michigan State University. Contact information is provided below.

What resources does this type of analysis require?

The TIMSS staff charges a fee for conducting the analysis. The fee depends on the extent of analysis, including such variables as district or school size, number of textbooks, and curriculum documents to be analyzed.

Contact information:

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OVERVIEW OF NATIONAL SCIENCE FOUNDATION REVIEW OF INSTRUCTIONAL MATERIALS FOR MIDDLE SCHOOL SCIENCE AND MATHEMATICS AND FRAMEWORK FOR REVIEW: INSTRUCTIONAL MATERIALS FOR MIDDLE SCHOOL MATHEMATICS

Background

In 1996, the National Science Foundation (NSF) undertook a study of comprehensive (at least one year) instructional materials for science in the NSF portfolio encompassing the middle-school years. This middle-school review was the first effort to examine a range of projects for a particular set of grades.

The major goals of NSF are to (1) provide the field with high-quality instructional materials that incorporate the best research on teaching and learning; (2) include accurate science and the active participation of scientists in the development process; and (3) have undergone an extensive pilot and field-test process. Support of such materials enables teachers, schools, and districts to have access to materials that provide students with experiences that lead to an understanding and mastery of scientific concepts and processes.

What issues does it address?

Alignment of materials with *NSES* and NCTM standards. Criteria include accuracy of the material presented, coverage of topics, pedagogical design (e.g., Do the materials provide for conceptual growth? How do they engage students?), assessment methods, support for implementation (e.g., Do the materials provide information on available resources and necessary support structures?), and equity (e.g., Are the materials likely to be interesting, engaging, and effective for underrepresented and underserved students?).

What materials does it examine?

Comprehensive sets of instructional materials—for example, a coordinated package of student books, hands-on materials, multimedia materials, assessments, and a teacher's guide designed to cover one or more years of instruction.

What is the frame of reference?

The *NSES* and NCTM standards.

What is the analysis process?

Teams of practicing scientists or mathematicians, educators, and assessment and implementation specialists review materials using a common review framework (included in this module). Team members assigned with specific portions of the materials review them individually, assign scores using the forms, and then meet to discuss their individual evaluations and develop a consensus assessment.

What are the potential uses at the local level?

The analytic method developed by NSF reflects three recognized dimensions of good instructional materials:

- **Alignment with *National Science Education Standards* or National Council of Teachers of Mathematics Standards.** This is useful to schools as they examine the coherence and alignment of their curricula with recognized national standards. Where local standards and frameworks are unique, schools and districts may wish to use the NSF review process but link it to their own standards. It provides valuable information on the rigor of their curricula and instructional materials.
- **Sound pedagogical design and logical development of conceptual understanding.** The NSF model asks evaluative questions that relate content and design and focuses on whether instructional materials reflect conceptual growth and provide students with opportunities to gain a better understanding of the information.
- **Provision for ongoing student assessment.** Materials that embed assessments within the instructional approach provide both students and teachers with a better picture of how well students are learning.

Does this analysis require outside assistance or special training?

Training is highly recommended to familiarize participants with the process and review criteria.

What resources does this type of analysis require?

For each team member involved, approximately five working days, broken down as follows:

1 day Team training

2 days Individual review of materials (can be spread over a longer period of time)

2 days Team discussion of individual reviews and consensus assessment

Contact information:

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Overview of American Association for the Advancement of Science (AAAS) Project 2061 Curriculum-Analysis Procedure

Background

With the growing consensus on what all students should know and be able to do in science, mathematics, and technology, educators now need a reliable method for identifying curriculum materials that will help students achieve those learning goals. Working with hundreds of K-12 teachers, materials developers, cognitive researchers, and scientists, Project 2061 has developed a systematic procedure for analyzing curriculum materials for alignment to specific learning goals. This procedure was created under a grant from the National Science Foundation and has been tested under field conditions by teachers at six sites around the country.

What issues does it address?

The Project 2061 Curriculum-Analysis Procedure focuses on three central concerns: What content does the curriculum material target? How well does that content align with specific learning goals such as benchmarks or standards? Does the material provide appropriate instructional strategies to help students learn the intended content? Project 2061's procedure offers a systematic approach to answering these questions.

The Project 2061 procedure identifies which specific learning goals the content of the material addresses, and estimates the effectiveness of its explicit instructional approaches for those specific learning goals. This is in contrast to procedures that make separate judgments about general topic coverage and general instructional quality.

What materials does it examine?

K-12 curriculum materials—ranging from short units to multiyear programs, including textbooks and their accompanying teachers' guides—that deal with the natural and social sciences, mathematics, and technology.

What is the frame of reference?

Project 2061's *Benchmarks for Science Literacy*, the National Research Council's *National Science Education Standards*, the National Council of Teachers of Mathematics' *Curriculum and Evaluation Standards for School Mathematics*, and, when they become available, ITEA Standards (*Technology for All Americans*). States can use their own frameworks or standards as the frame of reference, provided the learning goals are specific.

What is the analysis process?

Working as a team, reviewers first identify a sample of plausible specific learning goals against which to compare curriculum material. Next, they apply sets of analytical criteria to judge how well the material is aligned to the learning goals. This includes judgments about (1) how well the material's content matches the *specific* learning goals and (2) the extent to which the material's instructional strategy promotes student learning of the content. In a final report, reviewers summarize their findings, develop profiles for the materials, and present their conclusions.

What are the potential uses at the local level?

The AAAS Project 2061 Curriculum-Analysis Procedure provides districts/schools with a standards-based approach to evaluating instructional materials. For example, a school or district can use the procedure to consider the following:

- **Appropriateness of the content.** When selecting new materials or examining current offerings, a district will want to evaluate the extent to which textbooks and other curriculum materials are consistent with national, state, or local standards/frameworks and in line with learning goals for students at specific grade levels.
- **Utility of the instructional design.** Paying attention to the underlying instructional strategy of curriculum materials will help the district or school decide whether the materials will help students meet its expectations.

Does this analysis require outside assistance or special training?

Depending on audience and purpose, at least three to five days of training are recommended, which includes practice analyzing actual materials. Some groups might want additional time to familiarize themselves with *Bench-*

marks for Science Literacy or other standards documents to which they want materials to align. Project 2061 will publish a training manual in 1998 ("Resources for Science Literacy: Curriculum Evaluation") as part of a CD-ROM/ print tool, which will provide step-by-step instructions for the procedure, along with case studies of analyzed materials. In the meantime, interested educators can contact Project 2061 for information about training opportunities.

What resources does this type of analysis require?

Personnel—At least two individuals should review the material independently so that they can compare and reconcile results. The number of reviewers required naturally depends on the magnitude and scope of what is being reviewed. For looking at units, two individuals might suffice, but for looking at larger curriculum components, across grades or disciplines, teams that collectively have the necessary subject-matter and grade-level expertise are needed.

Materials—In addition to the curriculum material under consideration, reviewers will need Project 2061's *Resources for Science Literacy: Curriculum Evaluation* (available in 1998). *Resources* will also provide detailed comparisons of *Benchmarks for Science Literacy* and national standards in science, mathematics, and technology. Reviewers will also need copies of *Benchmarks for Science Literacy, Technology for All Americans,* and the relevant set of national (or local) standards against which they want to evaluate materials. Many reviewers will also find *Benchmarks for Science Literacy on Disc* very useful, with its search feature and sample growth-of-understanding maps.

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Overview of California Department of Education Curriculum Frameworks and Instructional Resources: Mathematics Instructional Materials Evaluation Instrument and Rating Form

Background

For use in grades one through eight, the California State Board of Education has the constitutional authority to adopt textbooks, based on their consistency with the State Board's curriculum frameworks. The state's Curriculum Commission recommends and the State Board appoints a panel of individuals to conduct an in-depth review of the textbooks. After reviewing the textbooks, the panel makes recommendations to the Curriculum Commission. This *Guidebook* contains the evaluation form for use by panels when evaluating mathematics textbooks in grades K-8.

What issues does it address?

Alignment of instructional resources with California state standards for mathematics. Criteria for mathematics include: mathematical content, program organization and structure, the work students do, student diversity (how the program deals with diversity in backgrounds, abilities, and interests), integration of assessment and instruction, and support for the teacher.

What materials does it examine?

Designed for textbooks, it can also be used for other instructional resources, such as technology-based resources or manipulative kits.

What is the frame of reference?

Mathematics Frameworks for California Public Schools, Kindergarten Through Grade Twelve.

What is the analysis process?

Panels of reviewers evaluate materials using a common form (included in this *Guidebook*). Team members review materials, assign scores individually using the forms, and then meet to discuss their individual evaluations and develop a consensus assessment.

What are the potential uses at the local level?

The methods developed for the state of California provide a technique for rating different sets of materials with a numeric score. By using this technique, a school or district can:

- **Compare different sets of instructional materials to a scoring rubric.** When examining different textbook series, a school or district will be able to compare and contrast the materials using a standard weighted rubric.
- **Establish different weights for review criteria.** This method of analysis provides weighted criteria across six areas. The relative percentages can be changed to emphasize different perspectives.
- **Substitute another framework.** The areas of emphasis and relative weights were determined by the California mathematics framework. If another framework is used, it should be closely examined and the relative weights aligned to the emphasis of the other framework.

Does this analysis require outside assistance or special training?

Experts on the California frameworks (or on those frameworks used in place of them) should meet with panel members to familiarize them with the frameworks.

What resources does this type of analysis require?

For each team member involved, approximately five working days, broken down as follows:

1 day Team training

3 days Individual review of materials
(can be spread over a longer period of time)

1 day Team discussion of individual reviews and consensus assessment

Contact information: Curriculum Frameworks and
Instructional Resources Office
California Department of Education
721 Capitol Mall, Sixth Floor
P.O. Box 94472
Sacramento, CA 94244-2720
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23

Overview of Council of Chief State School Officers (CCSSO) State Curriculum Frameworks and Standards Map: Definitions of Categories and Concepts

Background

The Council of Chief State School Officers (CCSSO) conducted a comprehensive study of the status, characteristics, and quality of state curriculum frameworks and standards in mathematics and science. An initial report in 1995 described the process of development of state frameworks and standards in the 1990s. In 1997, CCSSO released a second report addressing new frameworks and standards completed by the end of 1996, which included a total of 32 states. A key component of the study was a "Conceptual Map of State Frameworks and Standards." The map categorized and described state frameworks and standards documents across 14 concepts or "elements."

What issues does it address?

The findings are intended for use in identifying states (or districts) with specific standards in mathematics and science, in finding information in the documents on how standards can be applied and used with schools, and in providing examples of the different ways states have addressed development of frameworks and standards.

The mapping elements include sources of information; development process; funding; pages; year; number and types of content standards; number and types of benchmarks/indicators; related state documents; communication methods; equity and inclusion; pedagogy; assessment; professional development; and the use of technology, materials, and texts.

What materials does it examine?

Curriculum frameworks, content standards, other state and district guidance on curriculum development.

What is the frame of reference?

A set of elements developed by the CCSSO expert panel, based on national professional standards publications, international frameworks, and a reading of a sample of state frameworks and standards.

What is the analysis process?

Definitions and categories are specified for each element. Documents are thoroughly read by two trained research staff who code the documents against the analysis categories. Codes, examples, brief descriptions, and state definitions are entered into a database.

What are the potential uses at the local level?

This method of analysis was created to look across frameworks and develop a comprehensive model of state frameworks and standards. At the school or district level, potential uses include:

- **Comparison of local standards/frameworks with state standards.** This is useful to local communities developing their own frameworks or standards for seeing how they compare within their own states or to other neighboring states.
- **Analysis of state standards and frameworks.** A school, district, or consortium of districts may need to analyze the state standards prior to evaluating a set of instructional materials. This will be particularly important if a state assessment is in progress.

Does the analysis require outside assistance or special training?

Training for two to three days is needed. Research staff should have expertise in mathematics and/or science education. For assistance, see contact information.

What resources does this type of analysis require?

The analysis of each state document requires, on average, about three days. This assumes the staff has been trained, has been oriented to the task, and has done a pilot analysis. Two staff analyze the same document, and another staff person monitors any differences in categorization and coding.

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TIMSS Curriculum and Textbook Analysis

Introduction

> *"International achievement tests tell us what and how well students in the United States have learned compared to students in other countries, but are all U.S. students expected to learn the same things? Are our students expected to learn more or less material than other students, and when are they expected to learn it?"*

These are the types of questions the TIMSS curriculum analysis attempted to answer. TIMSS is the third large-scale international study of mathematics and science education conducted by the International Association for the Evaluation of Educational Achievement (IEA). The first two studies focus almost exclusively on comparing student achievement. While the achievement data indicate how students compare to each other on a common examination, they leave unanswered whether all students study the same material or are taught in similar settings with similar techniques. Therefore, TIMSS took a broader look at the factors contributing to achievement, particularly curriculum, instruction, and the environments of students and teachers. One purpose was to shed more light on achievement data, but the study also was designed to provide a much more sophisticated understanding of educational practices. The goal was not to judge which countries had "good" or "bad" curricula and instructional practices, but rather to analyze and compare them.

The TIMSS Curriculum Frameworks

The first step in comparing mathematics and science education across countries was to develop a common, international frame of reference for talking about learning goals. The results are the TIMSS curriculum frameworks for mathematics and science (see Figure 1 on page 29). These frameworks cover all of the years of schooling. They consider three aspects of curricula: (1) content—subject matter topics, (2) performance expectations—what students are expected to do with particular content, and (3) perspectives—overarching themes connecting subject matter to its place among the disciplines and the everyday world. By using this classification system, any curriculum component can be described by a "signature" consisting of categories and subcategories from each of the three aspects. Again, the frameworks are not meant to serve as statements regarding what a curriculum *should* include, but to help describe what a curriculum *does* include.

Content

The most immediate questions regarding curriculum center around whether students from different countries are studying similar material and, if not, how the curricula differ. Figure 1 lists the content categories for both mathematics and science. In science, the eight content categories are further divided into 47 subcategories with 66 subordinate subcategories. In mathematics, the 10 categories are further divided into 29 subcategories and 20 subordinate subcategories. The complete content frameworks for mathematics and science can be found in Figures 6 and 7 on pages 35 and 38, respectively. Comparisons using the content frameworks help identify whether students in different countries are expected to study similar material.

Performance Expectations

In addition to the topics covered, TIMSS researchers investigated expectations of what students are to do with the knowledge they acquire. As the framework indicates, performance expectations range from understanding information to applying it in theorizing, problem solving, and investigation. Comparing different curricula to the performance expectations framework can help identify which curricula place greater emphasis on understanding and which tend to emphasize application.

Perspectives

The goal of the perspectives framework is to identify broader goals for teaching mathematics and science than either acquisition of knowledge or development of skills. These goals include developing positive attitudes toward the subject matter and careers in the field. The materials in this module focus primarily upon content and performance expectations.

Figure 1. The TIMSS Science and Mathematics Curriculum Frameworks

Science	Mathematics
Content Categories	
1.1 Earth Sciences 1.2 Life Sciences 1.3 Physical Sciences 1.4 Science, Technology, and Mathematics 1.5 History of Science and Technology 1.6 Environmental and Resource issues related to science 1.7 Nature of Science 1.8 Science and other disciplines	1.1 Numbers 1.2 Measurement 1.3 Geometry: Position, Visualization, and Shape 1.4 Geometry: Symmetry, Congruence, and Similarity 1.5 Proportionality 1.6 Functions, Relations, and Equations 1.7 Data Representation, Probability, and Statistics 1.8 Elementary Analysis 1.9 Validation and Structure 1.10 Other content
Performance Expectations Categories	
2.1 Understanding 2.2 Theorizing, analyzing, and solving problems 2.3 Using tools, routine procedures, and science processes 2.4 Investigating the natural world 2.5 Communicating	2.1 Knowing 2.2 Using routine procedures 2.3 Investigating and problem solving 2.4 Mathematical reasoning 2.5 Communicating
Perspectives Categories	
3.1 Attitudes toward science, mathematics, and technology 3.2 Careers in science, mathematics, and technology 3.3 Participation in science and mathematics by underrepresented groups 3.4 Science, mathematics, and technology to increase interest 3.5 Safety in science performance 3.6 Scientific habits of mind	3.1 Attitudes toward science, mathematics, and technology 3.2 Careers in science, mathematics, and technology 3.3 Participation in science and mathematics by underrepresented groups 3.4 Science, mathematics, and technology to increase interest 3.5 Scientific and mathematical habits of mind

Analyses Performed and Examples of Questions They Answer

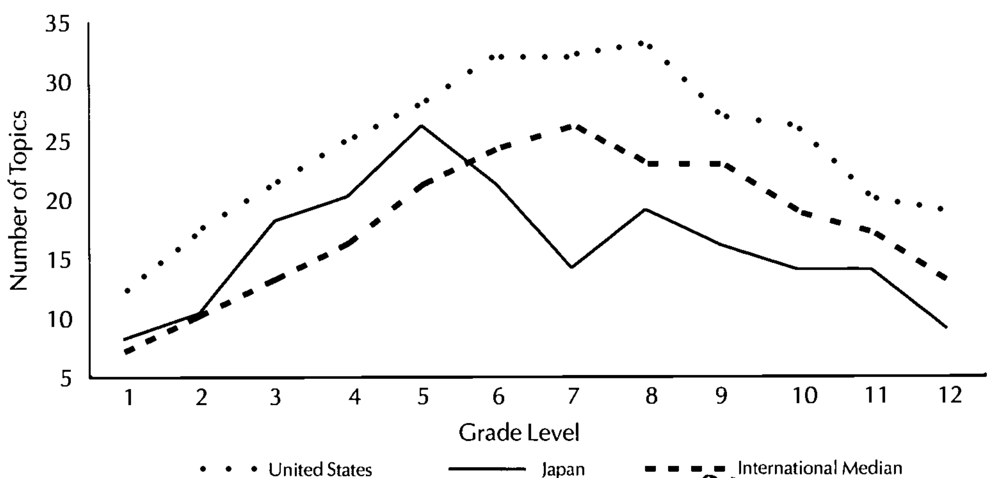
Using this framework, TIMSS researchers conducted two types of analyses to compare mathematics and science curricula. These analyses were intended to answer questions about topic inclusion, curriculum depth and breadth, and relative emphasis placed on various topics. TIMSS researchers also conducted a survey of seventh- and eighth-grade teachers in Japan, Germany, and the United States.

Topic Trace Mapping (of content)

In this procedure, a panel of curriculum experts in each country identified the grade levels at which particular topics from the TIMSS framework are included in their country's curriculum frameworks. (It should be noted that, unlike the United States, most countries have national curriculum guidelines.) Doing so allowed researchers to draw a "map" of all grade levels showing when each topic enters and leaves the curriculum and how long it stays. It also allowed comparisons of the total number of topics included in the curriculum at each grade level. The data can be used to answer a large number of research questions regarding both the "life" of topics in the curriculum over all years of schooling and topic "profiles" of each grade level. Comparisons can be made with specific countries or as an international composite. Following are three questions addressed in the study and the results.

(1) How many topics do we plan to cover at each grade level?

Figure 2. Number of Mathematics Topics Intended



(2) What is the number of topics added and dropped at each grade level?

FIGURE 3. NUMBER OF SCIENCE TOPICS ADDED AND DROPPED AT EACH GRADE LEVEL

Grade Level	Country	Topics Added	Topics Dropped	Net Gain (or Loss)	Cumulative Number of Topics
1	United States	21	0	21	21
	Germany	4	0	4	4
	Japan	0	0	0	0
2	United States	0	0	0	21
	Germany	0	0	0	4
	Japan	0	0	0	0
3	United States	1	0	1	22
	Germany	5	0	5	9
	Japan	15	0	15	15
4	United States	1	0	1	23
	Germany	32	0	32	41
	Japan	2	0	2	17
5	United States	15	0	15	38
	Germany	1	0	1	42
	Japan	5	0	5	22
6	United States	5	0	5	43
	Germany	15	1	14	56
	Japan	7	0	7	29
7	United States	7	0	7	50
	Germany	9	3	6	62
	Japan	3	0	3	32
8	United States	2	0	2	52
	Germany	1	7	-4	58
	Japan	10	0	10	42
9	United States	2	0	2	54
	Germany	2	15	-13	45
	Japan	11	0	11	53
10	United States	1	10	-9	45
	Germany	3	8	-5	40
	Japan	6	5	1	54
11	United States	0	16	-16	29
	Germany	3	5	-2	38
	Japan	9	6	3	57
12	United States	2	12	-10	19
	Germany	0	11	-11	27
	Japan	0	1	-1	56

(3) How long do we plan to continue study of a topic? (In how many grades is it addressed?)

FIGURE 4. AVERAGE MATHEMATICS TOPIC DURATION

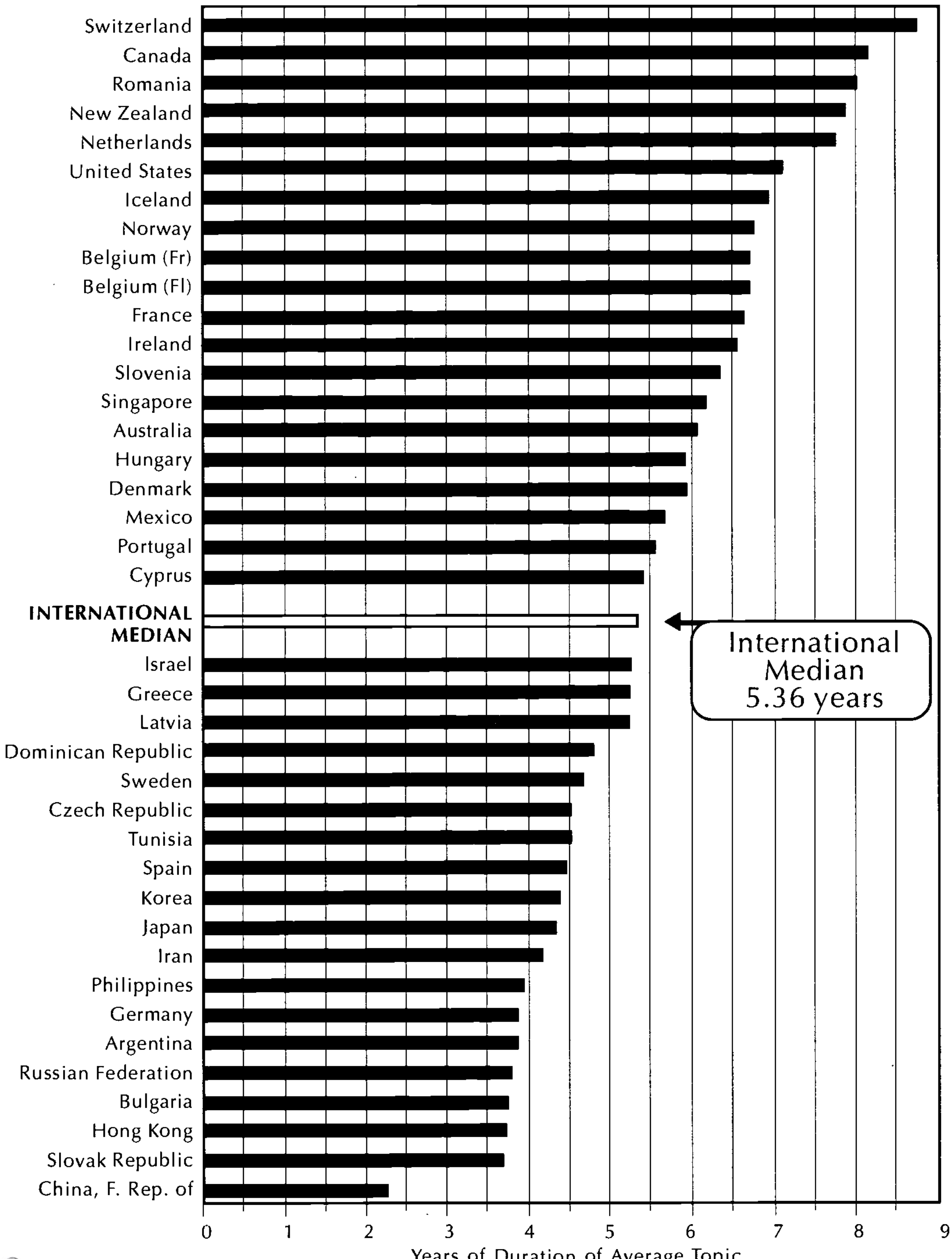


Figure 5. Curriculum Coverage for Selected Science Topics Across Student Ages

• topic covered in curriculum ■ topic emphasized in curriculum

Example 1: Earth Building & Breaking Processes

Country	6	7	8	9	10	11	12	13	14	15	16	17	18
France			•	•	•	•	•	■	•	•	■	•	
Japan								•	■	■	•	•	
Norway					•	•	•	•	•	•	•		
Spain						•	•	•	■	•	■	■	
Switzerland								•	•	■	■	•	
United States	•	•	•	•	•	•	•	•	■				

Example 2: Organs & Tissues

Country	6	7	8	9	10	11	12	13	14	15	16	17	18
France				•	•	■	■	■	■	■	■	■	
Japan			•	•	•	•	■	■	•	•	■	■	
Norway					•	•	•	•	•	•	•	•	
Spain			•	•	■	■	•	•	•	•	■	■	
Switzerland								•	•	■	■	•	
United States	•	•	•	•	•	•	•	•	■				

Example 3: Reproduction of Organisms

Country	6	7	8	9	10	11	12	13	14	15	16	17	18
France		•	•	•	•	■	■	■	•	•	■	■	
Japan					■				■	■			
Norway		•	•	•	•	•	•	■	•	■	•		
Spain				•	■	•	•	•	■	•	■	•	
Switzerland			•	•	•	•	•	•	■	■	•	•	
United States	•	•	•	•	•	•	•	•	■				

Example 4: Chemical Properties of Matter

Country	6	7	8	9	10	11	12	13	14	15	16	17	18
France								•	•	■	■	■	
Japan					•	■	•	■	■	•	■	■	
Norway					•	•	•	•	•	•	•	•	•
Spain						•	•	■	•	■	•	■	
Switzerland							•	•	•	■	■		
United States						•	•	•	•	•	■		

Note: Ages 9 and 13 are TIMSS Student Populations 1 and 2.

Document Analysis

The TIMSS study focuses on three different student populations: Population 1, students in the two consecutive grades with the majority of 9-year-olds; Population 2, students in the two consecutive grades with the majority of 13-year-olds; and Population 3, students in the final year of secondary school. For Populations 1 and 2, and for students in Population 3 specializing in mathematics and physics, researchers conducted an in-depth analysis of curriculum guides and textbooks using a two-step process:

(1) Researchers divided each document into *units*—major structural components—and *blocks*—smaller segments within units.

(2) Each of these units and blocks was then assigned content, performance expectation, and perspective category codes from the frameworks.

Several measures were taken to ensure uniformity and reliability across the large number of teams involved in the coding process. These included the development of detailed manuals on the procedures, intensive training sessions, and an initial quality-assurance phase in which teams were not allowed to begin their coding until they had been evaluated satisfactorily in a trial coding exercise by an international panel of referees.

With the documents fully coded, researchers were then able to describe and compare the science and mathematics curricula of different countries in terms of the topics and performance expectations included, their relative emphases, and the total number of content topics. Following are two questions addressed in the study and the results.

Which topics do we plan to cover?

Figures 6 and 7 show the topics from the TIMSS frameworks included in the curriculum guides and textbooks of the United States and a composite of the other participating countries. A "✓" means that the topic was listed in at least 70 percent of the curriculum guides or textbooks.

Figure 6. Topics Covered in Mathematics Curriculum Guides and Textbooks

TIMSS Framework of Content Categories and Subcategories	Population 1				Population 2					
	International Composite		United States		International Composite		United States			
							Non-Algebra		Algebra	
Curric. = Curriculum	Curric. Guides	Text-books	Curric. Guides	Text-books	Curric. Guides	Text-books	Curric. Guides	Text-books	Curric. Guides	Text-books
1.1 Numbers										
1.1.1 Whole numbers										
1.1.1.1 Meaning	✓	✓	✓	✓				✓		✓
1.1.1.2 Operations	✓	✓	✓	✓			✓	✓	✓	✓
1.1.1.3 Properties of operations	✓	✓		✓		✓		✓		✓
1.1.2 Fractions and decimals										
1.1.2.1 Common fractions	✓	✓	✓	✓		✓	✓	✓	✓	✓
1.1.2.2 Decimal fractions	✓		✓	✓		✓		✓		✓
1.1.2.3 Relationships of common and decimal fractions				✓		✓	✓	✓	✓	✓
1.1.2.4 Percentages						✓	✓	✓	✓	✓
1.1.2.5 Properties of common and decimal fractions										
1.1.3 Integer, rational, and real numbers										
1.1.3.1 Negative numbers, integers, and their properties				✓	✓	✓	✓	✓	✓	✓
1.1.3.2 Rational numbers and their properties					✓	✓		✓		✓
1.1.3.3 Real numbers, their subsets, and their properties					✓			✓		✓
1.1.4 Other numbers and number concepts										
1.1.4.1 Binary arithmetic and/or other number bases								✓		
1.1.4.2 Exponents, roots, and radicals					✓	✓		✓		✓
1.1.4.3 Complex numbers and their properties									✓	✓
1.1.4.4 Number theory				✓				✓		✓
1.1.4.5 Counting				✓				✓		

Figure 6. Topics Covered in Mathematics Curriculum Guides and Textbooks (continued)

TIMSS Framework of Content Categories and Subcategories	Population 1				Population 2					
	International Composite		United States		International Composite		United States			
							Non-Algebra		Algebra	
Curric. = Curriculum	Curric. Guides	Text-books	Curric. Guides	Text-books	Curric. Guides	Text-books	Curric. Guides	Text-books	Curric. Guides	Text-books
1.1.5 Estimation and number sense										
1.1.5.1 Estimating quantity and size				✓			✓	✓	✓	
1.1.5.2 Rounding and significant figures				✓			✓	✓	✓	
1.1.5.3 Estimating computations			✓	✓			✓	✓	✓	
1.1.5.4 Exponents and orders of magnitude							✓		✓	
1.2 Measurement										
1.2.1 Units	✓	✓	✓	✓		✓	✓	✓	✓	
1.2.2 Perimeter, area, and volume	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
1.2.3 Estimation and error			✓	✓			✓	✓	✓	
1.3 Geometry: position, visualization, and shape										
1.3.1 Two-dimensional geometry: coordinate geometry	✓		✓	✓	✓	✓	✓	✓	✓	✓
1.3.2 Two-dimensional geometry: basics	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
1.3.3 Two-dimensional geometry: polygons and circles	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
1.3.4 Three-dimensional geometry			✓	✓	✓	✓	✓	✓	✓	
1.3.5 Vectors							✓		✓	
1.4 Geometry: symmetry, congruence, and similarity										
1.4.1 Transformation	✓		✓	✓	✓	✓	✓	✓	✓	✓
1.4.2 Congruence and similarity			✓	✓	✓		✓	✓	✓	✓
1.4.3 Constructions using										

Figure 6. Topics Covered in Mathematics Curriculum Guides and Textbooks (continued)

TIMSS Framework of Content Categories and Subcategories	Population 1				Population 2					
	International Composite		United States		International Composite		United States			
							Non-Algebra		Algebra	
Curric. = Curriculum	Curric. Guides	Text-books	Curric. Guides	Text-books	Curric. Guides	Text-books	Curric. Guides	Text-books	Curric. Guides	Text-books
1.5 Proportionality										
1.5.1 Proportionality concepts				✓	✓		✓	✓	✓	✓
1.5.2 Proportionality problems					✓	✓		✓		✓
1.5.3 Slope and trigonometry								✓		✓
1.5.4 Linear interpolation and extrapolation										
1.6 Functions, relations, and equations										
1.6.1 Patterns, relations, and functions			✓	✓	✓	✓	✓	✓	✓	✓
1.6.2 Equations and formulas			✓	✓	✓	✓	✓	✓	✓	✓
1.7 Data representation, probability, and statistics										
1.7.1 Data representation and analysis		✓	✓	✓			✓	✓	✓	
1.7.2 Uncertainty and probability			✓	✓			✓	✓	✓	
1.8 Elementary analysis										
1.8.1 Infinite processes										
1.8.2 Change										
1.9 Validation and structure										
1.9.1 Validation and justification				✓				✓		✓
1.9.2 Structuring and abstracting				✓				✓		✓
1.10 Other content				✓				✓		✓
1.10.1 Informatics										
Total number of topics	11	9	18	29	16	18	24	37	24	27

FIGURE 7. TOPICS COVERED IN SCIENCE CURRICULUM GUIDES AND TEXTBOOKS

TIMSS Framework of Content Categories and Subcategories	Population 1				Population 2			
	International Composite		United States		International Composite		United States	
Curric. = Curriculum	Curric. Guides	Text-books	Curric. Guides	Text-books	Curric. Guides	Text-books	Curric. Guides	Text-books
1.1 Earth Sciences								
1.1.1 Earth features								
1.1.1.1 Composition								
1.1.1.2 Land forms				✓				✓
1.1.1.3 Bodies of water	✓			✓				✓
1.1.1.4 Atmosphere								✓
1.1.1.5 Rocks, soil					✓	✓		
1.1.1.4 Ice forms								✓
1.1.2 Earth processes								
1.1.2.1 Weather and climate	✓	✓		✓	✓	✓		✓
1.1.2.2 Physical cycles				✓				✓
1.1.2.3 Building and breaking								
1.1.2.4 Earth's history								✓
1.1.3 Earth in the universe								
1.1.3.1 Earth in the solar system	✓	✓		✓				✓
1.1.3.2 Planets in the solar system				✓				✓
1.1.3.3 Beyond the solar system								
1.1.3.4 Evolution of the universe								
1.2 Life Sciences								
1.2.1 Diversity, organization, and structure of living things								
1.2.1.1 Plants, fungi	✓	✓	✓	✓	✓	✓	✓	✓
1.2.12 Animals	✓	✓	✓	✓	✓	✓		✓
1.2.1.3 Other organisms				✓	✓			✓
1.2.1.4 Organs, tissues	✓	✓	✓	✓	✓	✓	✓	✓
1.2.1.5 Cells				✓	✓			✓

Figure 7. Topics Covered in Science Curriculum Guides and Textbooks (continued)

TIMSS Framework of Content Categories and Subcategories	Population 1				Population 2			
	International Composite		United States		International Composite		United States	
Curric. = Curriculum	Curric. Guides	Text-books	Curric. Guides	Text-books	Curric. Guides	Text-books	Curric. Guides	Text-books
1.2.2 Life processes and systems enabling life functions								
1.2.2.1 Energy handling				✓	✓	✓		✓
1.2.2.2 Sensing and responding				✓	✓	✓		✓
1.2.2.3 Biochemical processes in cells								
1.2.3 Life spirals, genetic continuity, and diversity								
1.2.3.1 Life cycles				✓	✓	✓		✓
1.2.3.2 Reproduction				✓	✓	✓		✓
1.2.3.3 Variation and inheritance								
1.2.3.4 Evolution, speciation, and diversity				✓	✓			✓
1.2.3.5 Biochemistry of genetics								
1.2.4 Interactions of living things								
1.2.4.1 Biomes and ecosystems			✓	✓	✓			✓
1.2.4.2 Habitats and niches				✓	✓			
1.2.4.3 Interdependence of life	✓	✓	✓	✓	✓	✓	✓	✓
1.2.4.4 Animal behavior				✓	✓			
1.2.5 Human biology and health	✓				✓			
1.2.5.1 Nutrition				✓				✓
1.2.5.2 Disease					✓	✓		✓
1.3 Physical Sciences								
1.3.1 Matter								
1.3.1.1 Classification of matter				✓	✓	✓		✓
1.3.1.2 Physical properties	✓	✓	✓	✓	✓	✓	✓	✓
1.3.1.3 Chemical properties				✓	✓	✓	✓	✓

FIGURE 7. TOPICS COVERED IN SCIENCE CURRICULUM GUIDES AND TEXTBOOKS (CONTINUED)

TIMSS Framework of Content Categories and Subcategories	Population 1				Population 2			
	International Composite		United States		International Composite		United States	
Curric. = Curriculum	Curric. Guides	Text-books	Curric. Guides	Text-books	Curric. Guides	Text-books	Curric. Guides	Text-books
1.3.2 Structure of matter								
1.3.2.1 Atoms, ions, and molecules				✓	✓	✓		✓
1.3.2.2 Macromolecules, crystals								
1.3.2.3 Subatomic particles					✓			✓
1.3.3 Energy and physical properties								
1.3.3.1 Energy types, sources, conversions	✓	✓	✓	✓	✓	✓	✓	✓
1.3.3.2 Heat and temperature					✓	✓		✓
1.3.3.3 Wave phenomena								
1.3.3.4 Sound and vibration				✓				✓
1.3.3.5 Light			✓	✓	✓	✓		
1.3.3.6 Electricity			✓	✓	✓	✓	✓	✓
1.3.3.7 Magnetism					✓			
1.3.4 Physical transformations								
1.3.4.1 Physical changes						✓		✓
1.3.4.2 Explanations of physical changes								
1.3.4.3 Kinetic theory								
1.3.4.4 Quantum theory and fundamental particles								
1.3.5 Chemical transformations								
1.3.5.1 Chemical changes								✓
1.3.5.2 Explanations of chemical changes					✓	✓		
1.3.5.3 Rate of change and equilibria								
1.3.5.4 Energy and chemical change								

Figure 7. Topics Covered in Science Curriculum Guides and Textbooks (continued)

TIMSS Framework of Content Categories and Subcategories	Population 1				Population 2			
	International Composite		United States		International Composite		United States	
Curric. = Curriculum	Curric. Guides	Text-books	Curric. Guides	Text-books	Curric. Guides	Text-books	Curric. Guides	Text-books
1.3.5.5 Organic and biochemical changes								
1.3.5.6 Nuclear chemistry								✓
1.3.5.7 Electrochemistry								
1.3.6 Forces and motion								
1.3.6.1 Types of forces				✓	✓	✓		✓
1.3.6.2 Time, space, and motion						✓	✓	✓
1.3.6.3 Dynamics of motion								
1.3.6.4 Relativity theory								
1.3.6.5 Fluid behavior								
1.4 Science, technology, and mathematics								
1.4.1 Nature or conceptions of technology								✓
1.4.2 Interactions of science, mathematics, and technology								
1.4.2.1 Influence of mathematics and technology on science								
1.4.2.2 Applications of science in mathematics and technology				✓	✓	✓		✓
1.4.3 Interactions of science, technology, and society								
1.4.3.1 Influence of science and technology on society				✓	✓	✓		✓
1.4.3.2 Influence of society on science and technology								
1.5 History of science and technology				✓		✓		✓

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FIGURE 7. TOPICS COVERED IN SCIENCE CURRICULUM GUIDES AND TEXTBOOKS (CONTINUED)

TIMSS Framework of Content Categories and Subcategories	Population 1				Population 2			
	International Composite		United States		International Composite		United States	
Curric. = Curriculum	Curric. Guides	Text-books	Curric. Guides	Text-books	Curric. Guides	Text-books	Curric. Guides	Text-books
1.6 Environmental and resource issues related to science								
1.6.1 Pollution	✓				✓	✓	✓	✓
1.6.2 Conservation of land, water, and sea resources	✓	✓		✓	✓	✓		✓
1.6.3 Conservation of material and energy resources	✓			✓	✓	✓		✓
1.6.4 World population	✓				✓			
1.6.5 Food production and storage	✓			✓	✓			✓
1.6.6 Effects of natural disasters					✓			✓
1.7 Nature of science								
1.7.1 Nature of scientific knowledge				✓	✓		✓	✓
1.7.2 The scientific enterprise				✓				✓
1.8 Science and other disciplines								
1.8.1 Science and mathematics				✓				✓
1.8.2 Science and other disciplines				✓				✓
Total number of topics	15	9	9	40	39	29	10	50

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What do we expect students to do with the content we plan to cover?

Figure 8 below indicates the performance expectations from the TIMSS mathematics framework included in the curriculum guides and textbooks in the United States and a composite of other participating countries. A "✓" means that the performance expectation was listed in at least 70 percent of the curriculum guides or textbooks.

FIGURE 8. PERFORMACE EXPECTATIONS INCLUDED IN MATHEMATICS CURRICULUM GUIDES AND TEXTBOOKS

TIMSS Framework of Content Categories and Subcategories	Population 1				Population 2					
	International Composite		United States		International Composite		United States			
							Non-Algebra		Algebra	
Curric. = Curriculum	Curric. Guides	Text-books	Curric. Guides	Text-books	Curric. Guides	Text-books	Curric. Guides	Text-books	Curric. Guides	Text-books
2.1 Knowing										
2.1.1 Representing	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
2.1.2 Recognizing equivalents	✓	✓		✓	✓	✓		✓		✓
2.1.3 Recalling mathematical objects and properties	✓	✓	✓	✓	✓	✓		✓		✓
2.2 Using routine procedures										
2.2.1 Using equipment	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
2.2.2 Performing routine procedures	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
2.2.3 Using more complex procedures	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
2.3 Investigating and problem solving										
2.3.1 Formulating and clarifying problems and situations	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
2.3.2 Developing strategies	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
2.3.3 Solving	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓

FIGURE 8. PERFORMACE EXPECTATIONS INCLUDED IN MATHEMATICS CURRICULUM GUIDES AND TEXTBOOKS (CONTINUED)

TIMSS Framework of Content Categories and Subcategories	Population 1				Population 2					
	International Composite		United States		International Composite		United States			
							Non-Algebra		Algebra	
Curric. = Curriculum	Curric. Guides	Text-books	Curric. Guides	Text-books	Curric. Guides	Text-books	Curric. Guides	Text-books	Curric. Guides	Text-books
2.3.4 Predicting	✓		✓	✓	✓	✓	✓	✓	✓	✓
2.3.5 Verifying	✓		✓	✓	✓	✓	✓	✓	✓	✓
2.4 Mathematical reasoning										
2.4.1 Developing notation and vocabulary	✓			✓	✓		✓	✓	✓	
2.4.2 Developing algorithms	✓			✓				✓		✓
2.4.3 Generalizing			✓	✓	✓	✓	✓	✓	✓	✓
2.4.4 Conjecturing			✓	✓	✓	✓	✓	✓	✓	✓
2.4.5 Justifying and proving			✓	✓	✓	✓	✓	✓	✓	✓
2.4.6 Axiomatizing										
2.5 Communication										
2.5.1 Using vocabulary and notation			✓	✓	✓	✓	✓	✓	✓	✓
2.5.2 Relating representations			✓	✓	✓	✓	✓	✓	✓	✓
2.5.3 Describing and discussing			✓	✓	✓	✓	✓	✓	✓	✓
2.5.4 Critiquing				✓				✓		✓
Total number of topics	13	9	16	20	18	17	16	20	16	19

FIGURE 9. PERCENT OF TEXTBOOK SPACE DEVOTED TO MAJOR POPULATION 2 SCIENCE PERFORMACE EXPECTATIONS

	Understanding	Theorizing, Analyzing, and Solving Problems	Using Tools, Routine Procedures, and Science Processes	Investigating the Natural World	Communicating
Argentina	71.0	11.0	12.0	0.0	1.0
Australia	79.0	7.0	8.0	7.0	7.0
Austria	80.0	8.0	2.0	7.0	2.0
Belgium (Fl)	47.0	11.0	34.0	10.0	5.0
Belgium (Fr)	15.0	3.0	9.0	10.0	6.0
Bulgaria	48.0	15.0	4.0	0.0	3.0
Canada	71.0	8.0	17.0	11.0	4.0
China, People's Rep. of	73.0	13.0	6.0	2.0	0.0
Colombia	98.0	3.0	0.0	0.0	0.0
Cyprus	70.0	12.0	10.0	8.0	0.0
Czech Republic	95.0	6.0	6.0	1.0	1.0
Denmark	73.0	3.0	18.0	10.0	0.0
Dominican Republic	29.0	16.0	2.0	19.0	1.0
France	68.0	16.0	16.0	1.0	1.0
Germany	55.0	15.0	30.0	0.0	0.0
Greece	90.0	6.0	1.0	0.0	0.0
Hong Kong	74.0	2.0	23.0	0.0	0.0
Hungary	87.0	2.0	8.0	2.0	0.0
Iceland	94.0	2.0	4.0	2.0	6.0
Iran	100.0	0.0	0.0	0.0	0.0
Ireland	85.0	2.0	4.0	6.0	1.0
Israel	77.0	3.0	10.0	1.0	0.0
Italy	85.0	8.0	5.0	3.0	1.0
Japan	82.0	7.0	13.0	10.0	2.0
Korea75.0	19.0	8.0	2.0	0.0	
Latvia	52.0	4.0	13.0	7.0	0.0
Lithuania	87.0	12.0	6.0	1.0	1.0
Mexico	92.0	3.0	9.0	2.0	3.0
Netherlands	58.0	16.0	10.0	4.0	1.0
New Zealand	56.0	4.0	26.0	21.0	8.0
Norway	72.0	4.0	5.0	14.0	3.0
Portugal	89.0	9.0	13.0	2.0	2.0
Romania	83.0	9.0	6.0	1.0	0.0
Russian Federation	88.0	15.0	7.0	1.0	1.0
Scotland	90.0	0.0	2.0	1.0	7.0
Singapore	76.0	3.0	3.0	19.0	0.0
Slovak Republic	86.0	12.0	9.0	2.0	1.0
Slovenia	85.0	14.0	5.0	2.0	0.0
South Africa	86.0	1.0	14.0	8.0	0.0
Spain	62.0	19.0	4.0	5.0	3.0
Sweden	72.0	7.0	2.0	8.0	3.0
Switzerland	79.0	7.0	1.0	5.0	1.0
Tunisia	93.0	3.0	1.0	2.0	0.0
United States	88.0	4.0	7.0	2.0	1.0

Teacher Survey

TIMSS researchers also surveyed seventh- and eighth-grade teachers in Japan, Germany, and the United States regarding the topics they actually cover in class, how much time they devote to each (using the TIMSS frameworks as references), their beliefs about pedagogical strategies, and the hours spent teaching each week. An example of the kind of question the survey answers is, "What are the topics most commonly taught?" Figure 10 presents the 10 topics most commonly taught in eighth-grade mathematics and science in the United States, Japan, and Germany, as reported by eighth-grade teachers.

Figure 10. The 10 Most Commonly Taught Topics in Eighth-Grade Mathematics and Science

United States	Japan	Germany
Mathematics Other Numbers and Number Concepts Number Theory and Counting Perimeter, Area, and Volume Estimation and Number Sense Percentages Two-Dimensional Geometry Proportionality Concepts Proportionality Problems Properties of Common and Decimal Fractions Relationships of Common and Decimal Fractions	Geometry: Congruence and Similarity Data Representation and Analysis Patterns, Relations, and Functions Two-Dimensional Geometry Proportionality Problems Other Content Estimation and Number Sense Proportionality Concepts Measurement: Estimation and Error Equations and Formulas	Equations and Formulas Perimeter, Area, and Volume Two-Dimensional Geometry Three-Dimensional Geometry and Vectors Measurement: Units Geometry: Congruence and Similarity Proportionality Problems Percentages Patterns, Relations, and Functions Other Numbers and Number Concepts
Science Nature of Science Structure of Matter Matter Science and Technology Mathematics Physical Transformations Environmental and Resource Issues Energy and Physical Processes Chemical Transformations Heat, Temperature, Wave, and Sound History of Science and Technology	Human Diversity Human Life Processes and Systems Chemical Transformations Structure of Matter Life Processes and Systems Matter Energy and Physical Processes Earth Processes Atmosphere Environmental and Resource Issues	Environmental and Resource Issues Nature of Science Energy and Physical Processes History of Science and Technology Heat, Temperature, Wave, and Sound Interactions of Living Things Structure of Matter Diversity, Organization, and Structure of Living Things Life Processes and Systems Matter

Other Curriculum-Analysis Methods

A. National Science Foundation (NSF) Review of Instructional Materials for Middle School Science and Framework for Review: Instructional Materials for Middle School Mathematics

B. American Association for the Advancement of Science (AAAS) Project 2061 Curriculum-Analysis Procedure

C. California Department of Education Curriculum Frameworks and Instructional Resources: Mathematics Instructional Materials Evaluation Instrument and Rating Form

D. Council of Chief State School Officers (CCSSO) State Curriculum Frameworks and Standards Map: Definitions of Categories and Concepts

National Science Foundation Review of Instructional Materials for Middle School Science

In 1996, the National Science Foundation (NSF) undertook a review of comprehensive curriculum projects in middle-school science. As work on the study progressed, it became clear that the framework for review developed to examine middle-school materials and the results of the panel's findings might be helpful beyond NSF and that they could be useful to those in the field working to improve science education in schools, districts, and states. The purpose of this paper is to make such information available to this broader audience.

Introduction

Unlike earlier school reforms, current reforms focus on identifying what all students should know and be able to do. Efforts such as NSF's Systemic Initiatives aim to create bold new visions of curriculum, assessment, and pedagogy to improve education for all children. The frameworks for these reforms are often found in national standards, such as those from the National Council of Teachers of Mathematics (NCTM) and the National Academy of Sciences' *National Science Education Standards (NSES).* These national frameworks were largely grassroots efforts with contributions from teachers, parents, school administrators, and scientists and mathematicians. They provide consensus views on what content is most important to teach, suggestions for teachers about effective instructional strategies, suggestions for how to assess student learning, and, in the case of the *NSES,* suggestions for implementation. In addition, the American Association for the Advancement of Science (AAAS) has developed *Benchmarks for Science Literacy,* a compendium of specific science literacy goals developed by scientists and educators that states, districts, and schools can use as a guide for a science curriculum.

Many states and districts have developed curriculum frameworks in mathematics and science that build on or adapt these standards efforts. The question now is, Do we have the tools required to successfully transverse the current educational terrain? The national and state frameworks perhaps set the compass and provide a large-scale map, but it falls on districts, schools, and teachers to identify the best materials and programs to make reform a reality. Without quality instructional materials, even the best teachers can make little headway.

To investigate the current status of instructional materials, NSF conducted a review of its portfolio of comprehensive curricula for middle-school science (grades 5 to 9) in early 1996. The justifications for starting with middle-level science included the following:

- Earlier NSF-funded projects had resulted in several sets of comprehensive materials at the elementary level.
- There were questions both in the field and at NSF about the availability of quality comprehensive materials for middle-school students.
- There were several sets of middle-school materials at or near completion and, therefore, ready for review.

The purpose of the Middle School Science Study was to answer the following questions:

1. What are the characteristics of the portfolio of comprehensive instructional materials for middle-school science developed with NSF funds?
2. How sufficiently do these materials provide for a comprehensive program for middle-school science consistent with the national standards for science education?

The study included a review of comprehensive curricula, those that equal a year or more of course material, produced during the past decade or that were currently under development. The central criteria used in reviewing the instructional materials were as follows:

1. Is the science content correct?
2. How well do the materials provide for conceptual growth in science?
3. How well do the materials align with the *National Science Education Standards*?

Rationale and Background—Overview and History of NSF's Instructional Materials Development Program (IMD)

It is NSF's goal to "achieve excellence in U.S. science, mathematics, engineering, and technology education at all levels."[1] One of the strategies for meeting this goal is to fund development of high-quality instructional materials with potential for national impact that are consistent with state and national standards. NSF, through the IMD Program, supports the development of new comprehensive materials and new instructional units and the revision of existing high-quality materials.

Developing high-quality instructional materials is an expensive and long-term process, requiring contributions from numerous teachers, scientists, and mathematicians to ensure that the content and pedagogy are current and correct. Materials should contain activities that are engaging for and relevant to students and should provide sufficient guidance for teachers so that they can successfully implement them in their classrooms. Materials must provide for extensive pilot and field testing with diverse student populations, and this often means time-consuming revisions. Materials supported by NSF are often under development for five years or longer before they are ready for publication. High-quality instructional materials are a critical component of the reform effort. Reform is not possible without materials that contain cutting-edge science; provide for students' conceptual growth over time; and contain engaging reading, experiments, and opportunities for teacher-directed student inquiry.

In sum, the IMD Program seeks projects that:

- Involve collaboration of scientists, mathematicians, teachers, and educators;
- Apply current research in teaching and learning;
- Align with standards;
- Contain embedded student assessments that help inform instruction and use a variety of strategies to assess student learning;
- Field-test materials in diverse settings; and
- Employ formative and summative evaluations that include student outcome data from field-test sites.[2]

Overview of Science Materials Reform

For mathematics, NSF funded a portfolio of projects to develop comprehensive instructional materials following the release of the National Council of Teachers of Mathematics *Standards for Content and Evaluation* in 1989[3]; however, NSF began funding the development of innovative comprehensive instructional materials in science a decade prior to the release of the science standards. The American Association for the Advancement of Science (AAAS) released *Benchmarks for Science Literacy*[4] in 1993, and the National Academy of Sciences/National Research Council published the *National Science Education Standards (NSES)*[5] in December 1995. Therefore, many of the middle-school projects reviewed in this study predate these standards. Many curriculum developers, however, served on the working groups that developed the *Benchmarks* and standards, participated in the extensive review and critique of the science standards, and incorporated ideas emerging from these standards-based projects in their materials.

The current cycle of development of instructional science materials, dating from the mid-1980s, is driven by (1) the need to ensure that there are effective materials available, particularly at the elementary level, where science is frequently relegated to "the last 20 minutes on Friday afternoon"; (2) the need to develop materials that provide more "hands-on" opportunities in which students can actively conduct their own observations and experiments and generate their own questions under teacher guidance; and (3) the need to incorporate new research findings in teaching and learning into science instructional materials.

In the mid-1980s, NSF funded hands-on materials at the elementary level, through the TRIAD projects. These projects formed partnerships among three critical groups—publishers, developers, and school districts—and operated on the assumption that the availability of high-quality elementary science materials would motivate teachers to teach science using a hands-on and inquiry-based approach. Shortly thereafter, work began on developing middle school materials, and this was followed by work on high school materials, many of which are now nearing completion.[6]

NSF has refined its ideas about what constitutes good instructional materials. NSF increasingly is concerned that materials provide appropriate

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guidance for teachers, suggest appropriate instructional strategies, contain a variety of assessment activities, accommodate the diversity of students, and contain suggestions for implementation. The review instrument developed by Inverness Research and modified by NSF for use in the Middle School Study reflects the Foundation's concern with assessing a wide range of features in addition to a high-quality content.

Procedures of the Middle School Science Study

The Middle School Science Study adapted NSF's peer review process to critique the portfolio of comprehensive curricula, using a method similar to that used by the IMD program for reviewing proposals for new projects. In this peer review process, panels of outstanding scientists, mathematicians, and educators critique proposals submitted for funding and make recommendations to the NSF about each proposal's quality, funding priority, and potential impact. Typically, reviewers provide individually written reviews, discuss the proposals in panel meetings, and develop a panel summary for each proposal. This study followed a four-step process in completing the review of materials: (1) training, (2) independent review, (3) summary and consensus, and (4) synthesis.

Training

A review panel of 20 experts comprising scientists, science and technology educators, and science teachers participated in the peer review process. For the peer review, program directors from the Division of Elementary, Secondary, and Informal Education (ESIE) met with the panel of experts to agree on the process and criteria for reviewing the materials. The panel used an instrument developed by Inverness Research to review one instructional module as a trial run in calibrating the review process. Following the trial review, the panel critiqued and revised the instrument to develop a common understanding for each item and to agree on the review process. Appendix A on page 61 includes a copy of the final review instrument, called the *Framework for Review.*

Independent Review

Following the panel meeting, panel members formed small working groups, comprising a scientist, science educator, practitioner, and individuals with expertise in assessment and implementation. Panel members read their assigned portions of the curriculum materials at home and prepared in-depth analyses of the materials using the review instrument as a framework for guiding their critiques. The panel members were asked to provide detailed justifications for their ratings for each item of the instrument.

Panel Summary

The panel members returned to NSF and exchanged results in their working groups. Each group prepared a written summary for each program representing a consensus of their reviews. The panel provided feedback on the review instrument and the review process, which NSF staff used to revise the instrument for future use. New summary groups were formed to discuss cross-cutting issues: (1) treatment of science content, (2) approach to teaching, (3) approach to assessment and equity, and (4) strategies for implementation. Each summary group reported to the whole panel and, through a large-group discussion, developed the major summary findings of the overall peer review.

Synthesis

A second panel of experts convened to review the process and findings of the peer review, to develop strategies for disseminating the findings, and to recommend future directions. The synthesis panel constituted 14 members, including four from the peer review panel. The synthesis panel included scientists, teachers, curriculum developers, and national and state leaders in the reform of science, mathematics, and technology education. The synthesis panel carefully reviewed the panel summaries and summary recommendations from the peer review process and developed an overall synthesis of findings that are the basis for this report.

Constraints

The review procedures were designed to provide a broad-brush assessment of the status of the portfolio of NSF-funded comprehensive instructional materials for middle school science. The purpose of the activity was to identify strengths and weaknesses in the portfolio, as well as gaps requiring the development or revision of projects. The intent of the study was to provide feedback to program officers who review proposals.

The study was *not* designed to (1) provide the NSF vision of a national curriculum, (2) thoroughly evaluate the individual projects, (3) offer a "consumer report" on quality of curricula, or (4) survey the needs of teachers and schools.

The study had several constraints:

- In most cases, the complete set of materials for one comprehensive program was not reviewed by all members of the panel. Therefore, each panel member completed the individual review based on only a subset of the full package of materials.
- No materials were reviewed by more than one panel; thus, it was not possible to equate a particular value on an item for one set of materials given by one panel with a value for the same item given by a different panel to another set of materials.
- Panel members analyzed, in general terms, the degree to which a set of materials addressed content standards within particular science disciplines, but did not do a fine-grained analysis of specific concepts and the amount of time allocated to the mastery of those specific concepts.

While the results of the study have shed light on the current status of middle-school science instructional materials developed with NSF funding, they do not serve as a detailed evaluation of the individual projects. It is hoped that the results of the study will be used to inform state and local administrators, curriculum developers, principal investigators of systemic reform and teacher enhancement projects, and NSF program officers about quality, standards-based instructional materials for middle school science. The review instrument developed as part of this study is an important product for use by those who select materials or school science programs.

Results—Overall

Thirteen of the 19 projects examined as part of NSF's Middle School Review had panel ratings of 3 or higher on a 1-5 point scale of the Inverness Research *Framework for Review,* with 1 as "low" and 5 as "high" on overall quality. Eight of these—*Prime Science* (6-10); *Science 2000* (6-8); *Science and Technology: Investigating Human Dimensions* (*BSCS,* 6-8); *Full Option Science*

System (*FOSS* 5-6); *Science and Technology for Children* (5-6); *Improving Urban Elementary Science* (*Insights* 5-6); *Elementary School Science and Health Materials* (*BSCS* 5-6); and *Integrated Mathematics, Science, and Technology* (*IMaST* 7-8)—are multiyear comprehensive programs. *Event-Based Science* and *Junior High/ Middle School Life Science Program (Jeffco)* comprise materials for one year. *Science Education for Public Understanding Program (SEPUP)* and its predecessor, *Chemical Education for Public Understanding Project (CEPUP),* cover non-sequential multiple single years of material, and a third set of materials, *Life Science for Public Understanding Project,* is currently under development in order to complete a comprehensive grade 7-10 series. *National Geographic Kids Network* (4-6) covers multiple grade levels but is not designed to cover a full year of science at any grade level. Therefore, the answer to the question regarding the availability of high-quality, standards-based middle-school science materials is that there are some good, comprehensive programs. Also, one-year programs can form important components of a total middle-school program. (See Appendix B for brief descriptions of these projects on page 97.)

Content

Science content in middle schools includes important scientific concepts in earth, biological, and physical sciences; opportunities for inquiry; and information on the history and processes of science. Particular programs stand out as having strengths in particular areas. These programs have the potential to serve as exemplars for curriculum developers who are designing new materials and for school districts that are forming school science programs.

Projects vary in their approach to content. A few developers have produced multiyear comprehensive programs designed to achieve all of the content standards for the middle level. These programs have been forced to face the challenge of finding the best balance between breadth and depth of science content. One example, *PRIME Science,* provides a balanced curriculum covering biological, earth, and physical sciences for grades 6 to 10 and revisits important concepts so students can deepen their understanding of key ideas. Another example, *Science 2000,* is rated high for its alignment with the *National Science Education Standards* content standards and its development of key science concepts. *Science 2000* is unique in that it is organized around a few major conceptual themes, and it has separate units on science and technology. *Integrated Mathematics, Science, and Technology (IMaST)* stands alone as a program that is designed to integrate the teaching of science and mathematics with technology. *IMaST* is designed to be taught by a team of mathematics, science, and technology teachers in a three-hour block and enables students to achieve the content standards in science and mathematics for the middle grades, with a grounding in technology education as well.

Single-year programs for the middle grades do not propose to meet all of the content standards for grades 5 to 9. Programs of this type either have developed materials aligned with a discipline-based approach (e.g., *Junior High/Middle School Life Science,* or *Event-Based Science: Earth Science)* or they have taken a problem/issue-centered approach that may transcend science disciplines (*CEPUP* and *SEPUP*). *Event-Based Science: Earth Science* takes both approaches in that it is a problem-centered program designed to teach the traditional content of earth science. *Event-Based Science* is rated high in its presentation of science content, and it is one of the few programs that addresses earth science. It effectively uses video footage of natural disasters (e.g., earthquakes, tornadoes, floods) to engage students in investigating the content and processes of earth science. The strength of the single-year approach is that a school district can build its own multiyear program by selecting single-year programs that fit their curriculum framework.

Comprehensive programs for grades 5 to 6 that are part of a K-6 program are challenged with the need to be both scientifically meaningful and developmentally appropriate for young students. *The Full Option Science System (FOSS)* for grades 5 to 6 is an example of the effective treatment of science content at this level. *FOSS* strikes a good balance between an emphasis on the major conceptual themes, such as systems, and an emphasis on science concepts, such as an electrical circuit. The reviewers felt that *FOSS* presents important current science content accurately, at a developmentally appropriate level, and covers appropriate breadth of science and depth of understanding.

PEDAGOGY

Good materials contain suggestions for teachers, such as sequencing activities to achieve desired learning results, and hints on working with groups of students. Particular programs have the potential to serve as exemplars for particular areas related to pedagogy. From the category of multiyear comprehensive programs, *PRIME Science* was rated highly by the panel for overall quality of pedagogical design. The panel members were especially impressed with the manner in which *PRIME Science* presents a logical progression of the development of conceptual understanding that reflects researchers' current understanding of the teaching and learning of science. *Science and Technology for Children* is a K-6 program that received high marks for engaging students in science inquiry and technology problem solving. *CEPUP* was recognized as providing a good model for using personal and social issues as the pedagogical driver for engaging students in learning and applying important science concepts. *National Geographic Kids Network* is unique in its effective use of telecommunications for engaging students in collaborative science investigations, and *Science 2000* provides a model for using interactive videodisc technology to engage students in learning science content.

Assessment

While classroom assessment is an important component of instructional materials, some of the materials (particularly those funded before the early 1990s) contained limited assessment activities. Other projects appear to include assessment as an afterthought. It is now believed that assessments should be developed concurrently with, and embedded in, the instructional materials. Some materials, such as *Junior High/Middle School Life Science Program (Jeffco)*, contain traditional assessments (paper-and-pencil tests), but they are well done. Others have greatly expanded on this traditional base by including assessments in which students demonstrate through performance or extended response questions what they know and are able to do. *Event-Based Science*, for example, is regarded as being very user-friendly for teachers and has excellent scoring rubrics that are related to the ongoing instructional themes. At the elementary level, *FOSS*, *Insights*, and *Science and Technology for Children* include embedded assessments that are integral to instruction and use a variety of approaches to test student understanding. *SEPUP* was cited as an outstanding example of embedded assessment at the middle-school level. *National Geographic Kids Network* also includes innovative uses of performance assessment linked to computer network communications.

Equity

Panel members described the approaches to equity in these materials as more likely to commit sins of omission than commission. Many of the materials simply do not address equity issues in any explicit way, although there is no obvious bias in the materials. Panel members felt that almost all of the materials would benefit from an explicit focus on equity issues and concrete suggestions for how teachers can gain access to needed materials and supplies, with an understanding that programs that rely on complex technologies may be expensive and thereby excluded in many schools and districts at the current time. Supplemental materials are needed that address the effective use of heterogeneous student groups and the importance of accommodating various learning styles. These materials may be produced by others than the curriculum developers.

Panel members lauded materials that focused on societal issues, such as *Event-Based Science, SEPUP,* and *Middle School Science and Technology* (*BSCS* 6-8), as having an inclusionary effect, because they address many issues using events and materials familiar and relevant to students. These integrated approaches provide access to important scientific ideas. Both sets of materials also discuss student learning styles and suggest cooperative learning strategies.

Implementation

Most of the materials packages in review do not address dissemination or implementation issues, and this is critical in focusing schools and districts on strategies for scaling up projects, exerting quality control, aligning curriculum, professional development and assessment, working effectively with parents and other community members, and so forth. Notable exceptions in this regard are the implementation guides including *Middle School Science and Technology* (*BSCS* 6-8) and *Junior High/Middle School Life Science Program (Jeffco).* Specific suggestions and strategies are provided for adopting new approaches to appropriate professional development, for scope and sequence of content, and for evaluating the effectiveness of implementing the materials. None of the materials packages mentions how to work with parents or the public.

Conclusions

There are a number of high-quality middle-school science curricula available, and some are comprehensive. With care and these materials, schools and districts can create good middle-school science programs.

A few key findings are:

- Most of the 13 sets of materials that rated 3 or higher on the 5-point scale are generally consistent with the national science content standards.
- The emphasis on science literacy for all students points to the importance of applying equity principles, but most materials do not explicitly address strategies for improving the performance of a diverse set of students through attention to differences in ability, learning style, and so on. Additional supplemental materials may be needed to provide good strategies.
- Among the content areas, earth science appears least frequently.
- Connections between science and mathematics are not developed in most of the materials.
- The greatest weakness in the set of materials relative to the science standards is the lack of sufficient focus on the history and nature of science.
- Too few materials incorporate significant and appropriate use of instructional technologies, such as ensuring that materials are presented in a variety of formats.

NOTES

[1]National Science Foundation, *NSF in a Changing World,* Arlington, VA (NSF95-24).
[2]National Science Foundation, *Elementary, Secondary, and Informal Education, Program Announcement and Guidelines,* 97-20.
[3]National Council of Teachers of Mathematics, *Curriculum and Evaluation Standards,* Reston, VA, 1989.
[4]American Association for the Advancement of Science, Project 2061, *Benchmarks for Science Literacy,* Oxford University Press, New York, 1993.
[5]National Research Council of the National Academy of Science, *National Science Education Standards,* Academy Press, 1995.
[6]Cozzens, Margaret, "Instructional Materials Development (IMD): A Review of the IMD Program, Past, Present, and Future," unpublished paper, National Science Foundation.

APPENDIX A

FRAMEWORK FOR REVIEW:
INSTRUCTIONAL MATERIALS FOR MIDDLE SCHOOL SCIENCE

Title: ____

Author(s): ____

Publisher: ______________________ Copyright date: ____________

Reviewed by: ____________________ Date: ____________________

I. Descriptors

a. Write a brief description of the components of the curriculum upon which this review is based (e.g., teacher's guide, student books, hands-on materials, multimedia material). That is, what materials did you receive and include in your review?

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b. Write a brief description of the purpose and broad goals of these materials. That is, what were the stated purposes, and what were the actual results of the materials?

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c. What grade levels do the materials serve?

____5 ____6 ____7 ____8

65

d. Are the instructional materials designed to

- ___ provide a complete multiyear program for middle school science.
- ___ provide a complete one-year course for middle school science.
- ___ provide multiple modules or units that could be used to supplement other course materials for middle school science.
- ___ provide a single module or collection of activities that could be used to supplement other course materials for middle school science.
- ___ other (explain): ______________________________

____

e. What are the major domains/topics of the content covered by these materials?

____

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II. Quality of the Science

Directions: For each item, circle the number corresponding with your response to the question.
Write an explanation for your rating of each item below the item.

a. Does the content in the instructional materials align well with all eight areas of the Content Standards as described in the *National Science Education Standards (NSES)*? (See attached guidelines.)

1	2	3	4	5
Omits substantial content included in *NSES* and/or includes substantial content not recommended in *NSES*		Some misalignment of content with recommendations in *NSES*		The curriculum aligns well with content recommendations in *NSES*

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b. Are the science concepts presented in the instructional materials accurate and correct? (Provide examples of major errors where they are evident. Attach extra page if necessary.)

1	2	3	4	5
Substantial, major errors		Mostly correct, with some minor errors		Scientifically accurate and correct

c. Do the instructional materials adequately present the major concepts in the standards and adequately demonstrate and model the processes of science?

1	2	3	4	5
Major concepts and processes not addressed		Major concepts and processes somewhat addressed		Major concepts and processes addressed well

d. Does the science presented in the instructional materials reflect current disciplinary knowledge?

1	2	3	4	5
The ideas are out of date		Somewhat current		Current

e. Do the instructional materials accurately represent views of science as inquiry as described in the *National Science Education Standards*?

1	2	3	4	5
Poor examples of inquiry		Mixed quality		Rich and accurate examples of inquiry

f. Do the instructional materials accurately present the history of science?

1	2	3	4	5
Poor portrayal of history of science		Mixed quality		Rich and accurate portrayal of history of science

g. Do the materials emphasize technology as an area of study?

1	2	3	4	5
Little or no emphasis		Some emphasis		Rich and well-designed emphasis

h. Do the materials emphasize the personal and societal dimensions of science?

1	2	3	4	5
Little or no emphasis		Some emphasis		Rich and well-designed emphasis

i. Do the materials emphasize the content of life science?

1	2	3	4	5
Little or no emphasis		Some emphasis		Rich and well-designed emphasis

j. Do the materials emphasize the content of earth science?

1	2	3	4	5
Little or no emphasis		Some emphasis		Rich and well-designed emphasis

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k. Do the materials emphasize the content of physical science?

1	2	3	4	5
Little or no emphasis		Some emphasis		Rich and well-designed emphasis

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l. Do the instructional materials provide sufficient activities for students to develop a good understanding of key science concepts?

1	2	3	4	5
Too few learning activities		Activities provide some opportunity for students to learn some important concepts		Activities provide many rich opportunities to learn key science concepts

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m. Do the instructional materials provide sufficient opportunities for students to apply their understanding of the concepts (i.e., designing of solutions to problems or issues)?

1	2	3	4	5
Very few application activities		Some application activities		Very rich in application activities

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n. Do the instructional materials present an accurate picture of the nature of science as a dynamic endeavor?

1	2	3	4	5
The image of science is out-of-date, inaccurate, or non-existent		The image of science is of mixed quality		The image of science is current and accurate

o. Do the materials develop an appropriate breadth and depth of science content?

1	2	3	4	5
Too narrow or too broad		Somewhat balanced		Good balance of breadth and depth

p. What is the overall quality of the science presented in the instructional materials?

1	2	3	4	5
Low		Medium		High

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III. The Pedagogical Design

a. Do the instructional materials provide a logical progression for developing conceptual understanding in science?

1	2	3	4	5
No logical progression of ideas		Somewhat logical progression of ideas		Logical progression of ideas that builds conceptual understanding

b. Do the instructional materials provide students with the opportunity to make conjectures, gather evidence, and develop arguments to support, reject, and revise their preconceptions and explanations for natural phenomena?

1	2	3	4	5
No opportunity		Some opportunity		Rich and well-designed opportunity

c. To what extent do the instructional materials engage students in doing science inquiry?

1	2	3	4	5
Very few or very contrived activities for students to do science inquiry		Some good activities for students to do science inquiry		Many rich and authentic opportunities for students to do science inquiry

d. To what extent do the instructional materials engage students in doing technology problem solving?

1	2	3	4	5
Very few or very contrived activities for students to do technology problem solving		Some good activities for students to do technology problem solving		Many rich and authentic opportunities for students to do technology problem solving

e. To what extent does the curriculum engage students in activities that help them connect science to everyday issues and events?

1	2	3	4	5
Very few or very contrived activities for students to make connections		Some good activities for students to make connections		Many rich and authentic opportunities for students to make connections

f. How would you rate the overall developmental appropriateness of the instructional materials, given their intended audience of ALL students at the targeted level(s)?

1	2	3	4	5
Not developmentally appropriate		Somewhat developmentally appropriate		Developmentally appropriate

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g. Do the materials reflect current knowledge about effective teaching and learning practices (e.g., active learning, inquiry, community of learners) based on research related to science education?

1	2	3	4	5
Do not reflect current knowledge about teaching and learning		Somewhat reflective of current knowledge about teaching and learning		Reflect well current knowledge about teaching and learning

h. Do the instructional materials provide students with the opportunity to clarify, refine, and consolidate their ideas, and to communicate them through multiple modes?

1	2	3	4	5
No opportunity		Some opportunity		Rich and well-designed opportunity

i. Do the instructional materials provide students with the opportunity to think and communicate scientifically?

1	2	3	4	5
No opportunity		Some opportunity		Rich and well-designed opportunity

j. Do the instructional materials provide students with activities connecting science with other subject areas?

1	2	3	4	5
No opportunity		Some opportunity		Rich and well-designed opportunity

k. Are the instructional materials likely to be interesting, engaging, and effective for students?

1	2	3	4	5
Not at all interesting		Somewhat interesting		Interesting and engaging

l. Are the instructional materials likely to be interesting, engaging, and effective for girls and for boys?

1	2	3	4	5
Gender biased		Some sensitivity to gender issues		Equally interesting, engaging, and effective for girls and for boys

m. Are the instructional materials likely to be interesting, engaging, and effective for underrepresented and underserved students (e.g., ethnic, urban, rural, with disabilities)?

1	2	3	4	5
Biased		Some sensitivity to underrepresented and underserved students		Equally interesting, engaging, and effective for underrepresented and underserved students

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n. Does assessment have explicit purposes connected with decisions to be made by teachers (e.g., prior knowledge, conceptual understanding, grades)?

1	2	3	4	5
Unclear purposes		Somewhat clear purposes		Clear statement of purposes

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o. Do assessments focus on the curriculum's important content and skills?

1	2	3	4	5
Poor correspondence		Fair correspondence		Full correspondence

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76

p. Do the instructional materials include multiple kinds of assessments (e.g., performance, paper/pencil, portfolios, student interviews, embedded, projects)?

1	2	3	4	5
Little or no student assessment provided		Some variety of student assessment		Complete student assessment package

q. Are the assessment practices fair to all students?

1	2	3	4	5
Fair to a few		Fair to most		Fair to all

r. Do the instructional materials include adequate and appropriate uses of a variety of educational technologies (e.g., video, computers, telecommunications)?

1	2	3	4	5
Little or no educational technology included		Some educational technology included		Many appropriate rich and useful applications of educational technology included

77

s. What is the overall quality of the pedagogical design of these instructional materials?

1	2	3	4	5
Low		Medium		High

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IV. Implementation and System Support

a. Will the teachers find the materials interesting and engaging?

1	2	3	4	5
Dry and boring		Somewhat interesting and engaging		Interesting and engaging

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b. Do the instructional materials include information and guidance to assist the teacher in implementing the lessons?

1	2	3	4	5
No teacher support		Some teacher support		Rich and useful teacher support

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c. Do the instructional materials provide information about the kind of resources and support system required to facilitate the district implementation of the required science materials?

1	2	3	4	5
No materials support		Some materials support		Rich and useful materials support

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d. Do the instructional materials provide information about how to establish a safe science learning environment?

1	2	3	4	5
No safety information		Some safety information		Rich and useful safety information

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e. Do the instructional materials provide information about the kinds of professional development experience needed by teachers to implement the materials?

1	2	3	4	5
Little or no information provided		Partial information provided		Rich and useful information provided

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79

f. Do the materials provide guidance in how to link the materials with the district and state assessment frameworks and programs?

1	2	3	4	5
No guidance		Some guidance		Rich and useful guidance

g. Do the materials provide guidance and assistance for actively involving administrators, parents, and the community-at-large in supporting school science?

1	2	3	4	5
No guidance		Some guidance		Rich and useful guidance

h. Overall, are the materials usable by, realistic in expectations of, and supportive of teachers?

1	2	3	4	5
Teacher-unfriendly		Somewhat teacher-friendly		Teacher-friendly

80

V. Major Strengths and Weaknesses

a. In your opinion, what are the three major strengths of this curriculum?

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b. In your opinion, what are the three major weaknesses of this curriculum?

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VI. Overall Quality, Value, and Contribution

a. In your opinion, what is the overall quality of these materials relative to:

	Low				High
■ turning students on to science?	1	2	3	4	5
■ making students think?	1	2	3	4	5
■ quality of science content?	1	2	3	4	5
■ quality of pedagogy?	1	2	3	4	5
■ quality of classroom assessments?	1	2	3	4	5
■ encouraging teachers to teach differently?	1	2	3	4	5

b. In your opinion, what is the overall quality of these instructional materials?

1	2	3	4	5
Low		Medium		High

c. To what extent would you encourage the dissemination, adoption, and implementation of this curriculum?

1	2	3	4	5
Not worthy of dissemination, adoption, or implementation		OK to disseminate, adopt, and implement if revised		OK to disseminate, adopt, and implement as is

FRAMEWORK FOR REVIEW:
INSTRUCTIONAL MATERIALS FOR MIDDLE SCHOOL MATHEMATICS

Title: ____________________

Author(s): ____________________

Publisher: ____________ Copyright date: ________

Reviewed by: ____________ Date: ________

I. Descriptors

a. Write a brief description of the components of the curriculum upon which this review is based (e.g., teachers' guide, student books, hands-on materials, multimedia material). That is, what materials did you receive and include in your review?

____

____

____

b. Write a brief description of the purpose and broad goals of these materials. That is, what were the stated purposes, and what were the actual results of the materials?

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____

____

c. What grade levels do the materials serve?

____5 ____6 ____7 ____8

d. Are the instructional materials designed to

___ provide a complete multiyear program for middle school mathematics?

___ provide a complete one-year course for middle school mathematics?

___ provide multiple modules or units that could be used to supplement other course materials for middle school mathematics?

___ provide a single module or collection of activities that could be used to supplement other course materials for middle school mathematics?

___ other (explain): ______________________________

____

e. What are the major domains/topics of the content covered by these materials?

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II. Quality of the Mathematics

Directions: For each item, circle the number corresponding with your response to the question. ***Write an explanation for your rating of each item below the item.***

a. Does the content in the instructional materials align well with all 13 areas of the Curriculum Standards as described in the National Council of Teachers of Mathematics' (NCTM) *Curriculum and Evaluation Standards for School Mathematics*? (See attached guidelines.)

1	2	3	4	5
Omits substantial content included in NCTM and/or includes substantial content not recommended in NCTM in NCTM		Some misalignment of content with recommendations		The curriculum aligns well with content recommendations in NCTM

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____

b. Are the mathematics concepts presented in the instructional materials accurate and correct? (Provide examples of major errors where they are evident. Attach extra page if necessary.)

1	2	3	4	5
Substantial, major errors		Mostly correct, with some minor errors		Mathematically accurate and correct

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84

c. Do the instructional materials adequately present the major concepts and adequately demonstrate and model the processes of mathematics?

1	2	3	4	5
Major concepts and processes not addressed		Major concepts and processes somewhat addressed		Major concepts and processes addressed well

d. Do the instructional materials accurately represent views of mathematical problem solving as described in the NCTM *Curriculum and Evaluation Standards for School Mathematics*?

1	2	3	4	5
Poor portrayal of problem solving		Mixed quality		Rich and accurate portrayal of problem solving

e. Do the materials use technology as a tool for learning mathematics?

1	2	3	4	5
Little or no use		Some emphasis		Rich and well-designed use

85

f. Do the materials emphasize communication about mathematics through a variety of modalities?

1	2	3	4	5
Little or no emphasis, few modalities		Some emphasis, some modalities		Rich and well-designed emphasis, varied modalities

g. Do the materials appropriately address mathematical reasoning?

1	2	3	4	5
Not appropriately addressed		Somewhat appropriately addressed		Appropriately addressed

h. Do the materials appropriately address computation?

1	2	3	4	5
Not appropriately addressed		Somewhat appropriately addressed		Appropriately addressed

i. Do the materials appropriately address estimation?

1	2	3	4	5
Not appropriately addressed		Somewhat appropriately addressed		Appropriately addressed

j. Do the materials appropriately address numbers and number relationships?

1	2	3	4	5
Not appropriately addressed		Somewhat appropriately addressed		Appropriately addressed

k. Do the materials appropriately address number systems and number theory?

1	2	3	4	5
Not appropriately addressed		Somewhat appropriately addressed		Appropriately addressed

l. Do the materials appropriately address patterns?

1	2	3	4	5
Not appropriately addressed		Somewhat appropriately addressed		Appropriately addressed

m. Do the materials appropriately address functions?

1	2	3	4	5
Not appropriately addressed		Somewhat appropriately addressed		Appropriately addressed

n. Do the materials appropriately address algebra?

1	2	3	4	5
Not appropriately addressed		Somewhat appropriately addressed		Appropriately addressed

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o. Do the materials appropriately address geometry?

1	2	3	4	5
Not appropriately addressed		Somewhat appropriately addressed		Appropriately addressed

____

____

____

____

p. Do the materials appropriately address measurement?

1	2	3	4	5
Not appropriately addressed		Somewhat appropriately addressed		Appropriately addressed

____

____

____

____

q. Do the materials appropriately address statistics?

1	2	3	4	5
Not appropriately addressed		Somewhat appropriately addressed		Appropriately addressed

____

____

____

____

r. Do the materials appropriately address probability?

1	2	3	4	5
Not appropriately addressed		Somewhat appropriately addressed		Appropriately addressed

s. Do the instructional materials provide sufficient activities for students to develop a good understanding of key mathematics concepts?

1	2	3	4	5
Too few learning activities		Activities provide some opportunity for students to learn some important concepts		Activities provide many rich opportunities to learn key mathematics concepts

t. Do the instructional materials provide sufficient opportunities for students to apply their understanding of the concepts (i.e., designing of solutions to problems or issues)?

1	2	3	4	5
Very few application activities		Some application activities		Very rich in application activities

90

u. Do the materials develop an appropriate breadth and depth of mathematics content?

1	2	3	4	5
Too narrow or too broad		Somewhat balanced		Good balance of breadth and depth

v. What is the overall quality of the mathematics presented in the instructional materials?

1	2	3	4	5
Low		Medium		High

III. The Pedagogical Design

a. Do the instructional materials provide a logical progression for developing conceptual understanding in mathematics?

1	2	3	4	5
No logical progression of ideas		Somewhat logical progression of ideas		Logical progression of ideas that builds conceptual understanding

91

b. Do the instructional materials provide students the opportunity to formulate, solve, and reflect critically on problems?

1	2	3	4	5
No opportunity		Some opportunity		Rich and well-designed opportunity

c. To what extent are the mathematical concepts embedded in learner-appropriate contexts?

1	2	3	4	5
Very few or very contrived activities for students to do mathematical problem solving		Some good activities for students to do mathematical problem solving		Many rich and authentic opportunities for students to do mathematical problem solving

d. How would you rate the overall developmental appropriateness of the instructional materials, given their intended audience of ALL students at the targeted level(s)?

1	2	3	4	5
Not developmentally appropriate		Somewhat developmentally appropriate		Developmentally appropriate

92

e. Do the materials reflect current knowledge (that is, in the last 5 years) about effective teaching and learning practices (e.g., active learning, inquiry, community of learners) based on research related to mathematics education?

1	2	3	4	5
Do not reflect current knowledge about teaching and learning		Somewhat reflective of current knowledge about teaching and learning		Reflect well current knowledge about teaching and learning

f. Do the instructional materials provide students the opportunity to clarify, refine, and consolidate their ideas?

1	2	3	4	5
No opportunity		Some opportunity		Rich and well-designed opportunity

g. Do the instructional materials provide students with activities connecting mathematics with other subject areas?

1	2	3	4	5
No opportunity		Some opportunity		Rich and well designed opportunity

93

h. Are the instructional materials likely to be interesting, engaging, and effective for girls and for boys?

1	2	3	4	5
No sensitivity to gender issues		Some sensitivity to gender issues		Sensitive to gender issues

___

___

___

___

i. Are the instructional materials likely to be interesting, engaging, and effective for underrepresented and underserved students (e.g., ethnic, urban, rural, with disabilities)?

1	2	3	4	5
No sensitivity to underrepresented and underserved students		Some sensitivity to underrepresented and underserved students		Sensitive to underrepresented and underserved students

___

___

___

___

j. Does assessment have explicit purposes connected with decisions to be made by teachers (e.g., prior knowledge, conceptual understanding, grades)?

1	2	3	4	5
Unclear purposes		Somewhat clear purposes		Clear statement of purposes

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k. Do assessments focus on the curriculum's important content and skills?

1	2	3	4	5
Poor correspondence		Fair correspondence		Full correspondence

l. Do the instructional materials include multiple kinds of assessments (e.g., performance, paper/pencil, portfolios, student interviews, embedded, projects)?

1	2	3	4	5
Little or no student assessment provided		Some variety of student assessment		Complete student assessment package

m. Are the assessment practices fair to all students?

1	2	3	4	5
Fair to a few		Fair to most		Fair to all

n. Do the instructional materials include adequate and appropriate uses of a variety of educational technologies (e.g., video, computers, telecommunications)?

1	2	3	4	5
Little or no educational technology included		Some appropriate educational technology included		Many rich and useful applications of educational technology included

o. What is the overall quality of the pedagogical design of these instructional materials?

1	2	3	4	5
Low		Medium		High

IV. Implementation and System Support

a. Will the teachers find the materials interesting and engaging?

1	2	3	4	5
Dry and boring		Somewhat interesting and engaging		Interesting and engaging

96

b. Do the instructional materials include information and guidance to assist the teacher in implementing the lessons?

1	2	3	4	5
No teacher support		Some teacher support		Rich and useful teacher support

c. Do the instructional materials provide information about the kind of resources and support system required to facilitate the district implementation of the required mathematics materials?

1	2	3	4	5
No materials support		Some materials support		Rich and useful materials support

d. Do the instructional materials provide information about the kinds of professional development experience needed by teachers to implement the materials?

1	2	3	4	5
Little or no information provided		Partial information provided		Rich and useful information provided

e. Do the materials provide guidance in how to link the materials with the district and state assessment frameworks and programs?

1	2	3	4	5
No guidance		Some guidance		Rich and useful guidance

f. Do the materials provide guidance and assistance for actively involving administrators, parents, and the community-at-large in supporting school mathematics?

1	2	3	4	5
No guidance		Some guidance		Rich and useful guidance

g. Overall, are the materials usable by, realistic in expectations of, and supportive of teachers?

1	2	3	4	5
Teacher-unfriendly		Somewhat teacher-friendly		Teacher-friendly

98

V. Major Strengths and Weaknesses

a. In your opinion, what are the three major strengths of this curriculum?

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b. In your opinion, what are the three major weaknesses of this curriculum?

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VI. Overall Quality, Value, and Contribution

a. In your opinion, what is the overall quality of these materials relative to:

	Low				High
■ turning students on to mathematics?	1	2	3	4	5
■ making students think?	1	2	3	4	5
■ quality of mathematics content?	1	2	3	4	5
■ quality of pedagogy?	1	2	3	4	5
■ quality of classroom assessments?	1	2	3	4	5
■ encouraging teachers to teach differently?	1	2	3	4	5

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b. In your opinion, what is the overall quality of these instructional materials?

1	2	3	4	5
Low		Medium		High

c. To what extent would you encourage the dissemination, adoption, and implementation of this curriculum?

1	2	3	4	5
Not worthy of dissemination, adoption, nor implementation		OK to disseminate, adopt, and implement if revised		OK to disseminate, adopt, and implement as is

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APPENDIX B

This appendix contains a brief description of each set of instructional materials from the Middle School Science Study that are discussed in this report. The materials are grouped as follows:

- Comprehensive, multiple continuous years, grade 6 and beyond;
- Comprehensive, multiple continuous years, grades K-6;
- Comprehensive, integrated mathematics, science, and technology, grades 7-8;
- Single-year comprehensive; and
- Technology-driven supplemental, but material for at least a full year.

Comprehensive 6-10

Title: *PRIME Science*
Contact: Richard Saykally, University of California, Berkeley
Publisher: Kendall/Hunt Publishing Co.
4050 Westmark Drive
P.O. Box 1840
Dubuque, IA 52004
1 (800) 258-5622

PRIME Science provides a U.S. adaptation of "Salter's Science"—a well-tested British multidisciplinary science program for middle grades. The science is balanced—not integrated—between life, earth, and physical science, developing conceptual understanding and integrating mathematics, technology, and decision making. The science is rigorous, interesting, and useful to the student. Among the major integrative themes that provide structure for grades six through 10 are the earth in space, properties of matter, and so forth. Each unit begins with an application. The teachers' guides are directed at first-year teachers, not teaching in their major discipline. Included are student preconceptions, safety, background, and ways of introducing the content and assessment items. The visually stimulating, attractively designed student supplements for each of the 40 units contain the application, a summary of what students should know, what they need to learn, and the activities they can do. The materials were tested and rewritten by teachers and science educators at several sites throughout the United States. Professors at the University of California, Berkeley, reviewed the materials for content accuracy. The British developers were part of the design team. Not only does the adaptation involve language translation, but also changing data to interest U.S. audiences and adding units to meet local interests and frameworks.

Materials Reviewed: Sixth-grade materials developmental form were reviewed.

Strengths:

1. The program is planned to introduce science content at various grade levels and to revisit it as students advance to later grade levels. Content introduced in the sixth grade might be revisited several times in later grades, giving students opportunities to further develop their own understanding as they mature.
2. The activity-based approach gives students experiences with numerous science concepts in a way they will more likely remember and understand.
3. The teacher materials provide support for both the experienced teachers and those unfamiliar with the content being taught. It is flexible enough to allow teachers to supplement the curriculum with their own experiences and to integrate current events.

General Concerns:

1. Efforts should include more of the emerging technologies (e.g., CD-ROM).
2. More of the student challenges should be open ended to develop inquiry skills.
3. The program should include a greater variety of assessment items.

Comprehensive 6-8

Title: *Science 2000*
A Middle School Technology Based
Curriculum Management Tool
Contact: Ellen M. Nelson
Publisher: Decision Development Corp.
2680 Bishop Drive
Suite 122
San Ramon, CA 94583
(510) 830-8894

Science 2000 is a multimedia science curriculum for grades 5 to 8 that uses a constructive pedagogy, a thematic approach, and a multidisciplinary organization of science. At the sixth- to eighth-grade levels, four different thematic units integrate materials from earth, life, and physical science leading to a decision-making situation in which students apply knowledge to solve an STS-type problem. Grade six units are: Earth's Changing Environments, Growth and Development, Physics of Building, and Chemistry of Food. Eighth-grade units are: Genetics and Heredity, Sun and Global Climate Change, Ears to the Sky, and Natural Disasters. The large ideas of science and science as a method of knowing are stressed. Each unit includes teacher lessons, student activities, and bibliographic resources stored in software; a learning resource management tool compatible with either IBM or Macintosh computers, which allows teachers to choose, write, and edit lessons, as well as assign student activities, access videodiscs, and review supplemental material; four videodiscs; eight hands-on activities; and models for pre- and in-service teacher education. *Science 2000* correlates to the standards and has been adopted as a textbook alternative in Alabama, Florida, Georgia, Kentucky, Louisiana, Texas, Utah, and West Virginia.

Materials Reviewed: Units in grades 6 and 8 were reviewed.

Strengths:

1. The professional quality of the programs and the software are high, video clips and databases are current, and themes and story lines are engaging and appropriate.
2. The materials are diverse enough to support a variety of uses by both inquisitive students and creative teachers.
3. There is very good alignment with standards, and the focus on four major questions per year allows in-depth study. The thematic, problem-solving approach is question driven, and there are some open-ended questions.

General Concerns:

1. The actual assessment pieces are vague.
2. The program's complexity (extensions and flexibility) make the program difficult to use. The technology was very difficult to set up. Teachers will need considerable in-service training to use this program effectively.
3. The lack of text may cause problems with parents, and there are no materials for communicating with them.

Comprehensive 6-8

Title: *Middle School Science and Technology*
Contact: Michael Doherty, Biological Sciences Curriculum Study
Publisher: Kendall/Hunt Publishing Co.
4050 Westmark Drive
P.O. Box 1840
Dubuque, IA 52004
1 (800) 258-5622

Middle School Science and Technology is a three-year, activity-based, middle school program for grades 6 to 8 as a continuation of the Biological Sciences Curriculum Study (BSCS) K-6 program. It focuses on the development of the early adolescent, illustrates careers in science, and emphasizes reasoning and critical thinking. The content is structured around major themes of patterns of change, diversity and limits, and systems and change, with emphasis on personal dimensions of science and technology, science and technology in society, technological problem solving, and the nature of scientific explanation. The content is strongest in the life sciences, but generally aligns well with the content recommendations in the *National Science Education Standards (NSES).*

Materials Reviewed: Sixth-, seventh-, and eighth-grade materials were reviewed.

Strengths:

1. Emphasis is on development and use of good pedagogy; for example, the philosophy and approach to cooperative learning is thoroughly explained and consistently used.
2. There is excellent attention to professional development, teaching, program, system, assessment, as well as content; there is a high level of consistency with the standards.
3. The "less is more" approach is used to build an accurate understanding of overriding concepts and related subconcepts.

General Concerns:

1. The eighth-grade materials are not consistent with the format and approach so effectively used for grades six and seven. The quality of the introductory units is not equivalent to the other units.
2. The teacher support materials tend to be wordy to the detriment of easy understanding.
3. There is limited opportunity for students to develop and pursue questions of their own.

Comprehensive K-6

Title: *Science for Life and Living*
Contact: Catherine Monson, Biological Sciences Curriculum Study
Publisher: Kendall/Hunt Publishing Co.
4050 Westmark Drive
P.O. Box 1840
Dubuque, IA 52004
1 (800) 258-5622

Science for Life and Living is a K-6 elementary science program that encourages students to make decisions and take actions that will improve the quality of their lives. At each grade level, one major concept and one major skill integrate the disciplines, so that students can make meaningful connections between areas of study. For example, Level 1 ideas and concepts including the following: Introduction to Order and Organization—Objects and Properties (science), Materials and Structures (technology), Safety and Security (health). Major ideas in Levels 2-6 include the following: Level 2—Introduction to Change and Measurement; Level 3—Introduction to Patterns and Predictions; Level 4—Introduction to Systems and Analysis; Level 5—Introduction to Energy and Investigation; Level 6—Introduction to Balance and Decisions. The curriculum uses the Biological Sciences Curriculum Study instructional model, is based on constructivist learning theory, integrates cooperative learning, and includes kits of hands-on materials and an implementation guide for use by personnel in school districts and school buildings. The components of the program consist of: (1) two teachers' guides in three-ring binders for each level, K-6; (2) student materials for each level; (3) kits of hands-on materials for each level; and (4) an implementation guide for administrators and leadership teams within schools.

Materials Reviewed: Two levels, grades five (Energy and Investigation) and six (Balance and Decisions), of the curriculum were reviewed. Each level consisted of a teacher guide in the form of a notebook plus a student text. The *Implementation Guide* was also reviewed.

Strengths:

1. Teacher guide takes the teacher step-by-step through the curriculum—valuable for the science-timid teacher.
2. The materials utilize inexpensive supplies.
3. Team skills are taught.
4. The *Implementation Guide* for use by districts, principals, and schools is excellent.

General Concerns:

1. At times the content appears to be very thin.
2. There is too much focus on terms, and the content diagrams are somewhat unfriendly.
3. Hands-on, active learning is not always present; activities are more like demonstrations; mostly pencil-and-paper activities are used.

Comprehensive K-6

Title: *Full Option Science System (FOSS)*
Contact: Lawrence F. Lowry, Lawrence Hall of Science
Publisher: EBEC
310 South Michigan Avenue
Chicago, IL 60604
1 (800) 554-9862

The Full Option Science System (FOSS) for grades K-6 is offered to schools as a collection of standalone modules on different topics appropriate for students in grades K-6. The module consists of a kit of student materials, a detailed teacher's guide, and a teacher's preparation video. The activities are organized into four strands: Life Science, Physical Science, Earth Science, and Scientific Reasoning and Technology. Five unifying themes weave through the modules of the program: Pattern, Structure, Interaction, Change, and System. Student assessment suggestions are included. Four modules in any academic year would easily constitute a complete curriculum. Eight modules (two in each strand) have been developed to be appropriate for students in sets of grades K-2, 3-4, and 5-6. There are two language versions of all student materials packaged in each guide, Spanish and English. There are also suggestions for cultural enrichment, sensitivity to cultural difference, and sheltered instruction. *FOSS* employs cognitive and constructivist approaches to science instruction. Students work in collaborative groups of four to maximize effective use of materials and promote student-student interactions. Fundamental academic skills of language and mathematics are integrated into all activities, and guidance is provided to help teachers lead productive discussions.

Materials Reviewed: Units reviewed were Life Science: Food and Nutrition, and Environments; Physical Science: Levers and Pulleys, and Mixtures and Solutions; Earth Science: Solar Energy, and Landforms.

Strengths:

1. Materials are user friendly, clear, and clean; teachers' guides and videos are excellent.
2. Modules are built on a strong psychological and teaching research foundation.
3. There is strong science content with a good balance of depth and breadth.
4. Children will enjoy the cleverly designed activities and materials.
5. Assessments are strong; questioning approaches direct teachers regarding the types of questions to ask.

General Concerns:

1. Many of the hands-on science activities are excellent, but materials do not encourage students to ask their own questions.
2. Materials provide guided inquiry, but little open-ended inquiry.
3. Bibliography and history of science are thin.

Comprehensive K-6

Title: *Insights: A Hands-On Inquiry Science Curriculum*
Contact: Karen Worth, Education Development Center
Publisher: Optical Data Corporation
30 Technology Drive
Warren, NJ 07059
1 (800) 248-8478

The Education Development Center's *Insights* is a hands-on, inquiry-oriented science program designed for self-contained elementary classrooms. The science is appropriate and current, and the supplies required are inexpensive and easy to obtain. These materials are designed to improve students' abilities to think critically, use language, and solve problems using the natural world as an experimental base. Since urban systems face extremely complex problems, the science materials are specifically aimed at these systems. There is a balance of life, physical, and earth sciences, tying the experimental base to the urban setting where appropriate. The materials integrate science with the rest of the elementary curriculum, particularly language arts and mathematics.

Materials Reviewed: Six units were reviewed: Changes of State, grades 4-5; The Mysterious Powder, grades 4-5; Reading the Environment, grades 4-5; Structures, grade 6; There Is No Away, grade 6; and Human Body Systems, grade 6.

Strengths:

1. The topics are important for the age levels, with appropriate and current science.
2. The supplies called for are inexpensive.
3. Activities stretch over a period of time and allow exploration on the part of students.
4. Effective sequencing of the curriculum within the units (i.e., activities) provides good guidance for teachers; assessments are also good.

General Concerns:

1. Minor errors and inconsistencies exist and should be edited out.
2. The amount of information provided to teachers in the background text appears insufficient.
3. Assessment questions need to focus on topics that are familiar/ accessible to all students (an example of a bicycle activity would leave those without bicycles at a disadvantage).

Comprehensive K-6

Title: *Science and Technology for Children*
Contact: Douglas M. Lapp, National Science Resource Center, Smithsonian Institution, and National Academy of Sciences
Publisher: Carolina Biological Supply Co.
2700 York Road
Burlington, NC 27215
1 (800) 227-1150

The National Science Resource Center (NSRC) joined with the National Academy of Sciences and the Smithsonian Institution to bring together teachers, educators, and scientists with a great diversity and richness of experience to create and disseminate an innovative elementary science program for grades one through six called *Science and Technology for Children (STC)*. Twenty-four hands-on, inquiry-centered units constitute a complete elementary science program for grades one through six. In addition, there are 16 science readers to complement the 16 *STC* units for grades three through six. Each *STC* unit provides children with the opportunity for in-depth learning about topics in the physical, life, or earth sciences and technology through direct observation and experimentation. The units invite children first to develop hypotheses and then to test their ideas just as professional scientists do. Along the way, children develop patience, persistence, and confidence in their own ability to tackle and solve real problems. The teachers act as guides to the hands-on learning, encouraging students to explore new ideas for themselves and expand their understanding of the world around them. School districts are able to use these materials either collectively, as a complete elementary science program, or individually, as a supplement to an existing science program. These materials are designed to meet the needs of elementary school children from diverse cultural and ethnic backgrounds.

Materials Reviewed: Of the 24 units, those considered appropriate for fifth and sixth grades were Food Chemistry, Electric Circuits, Ecosystems, Animal Studies, Microworlds, Experiments with Plants, Measuring Time, and Floating and Sinking.

Strengths:

1. The program presents carefully sequenced, hands-on activities designed to lead to conceptual development.
2. Rich, strong, and accurate science content is a real strength.
3. The program is positively aligned with standards, including technology content and assessment.

General Concerns:

1. The materials are very teacher directed, with insufficient opportunity for students to ask and answer their own questions.
2. The teachers' guide has too much information that is hard to locate and use.

Integrated Comprehensive 7-8

Title: *Integrated Mathematics, Science and Technology*
Contact: Francie Loepp, Illinois State University
Publisher: Glen Co. Macmillan
3008 West Willow Knolls Drive
Peoria, IL 61614
(309) 438-3089

The *Integrated Mathematics, Science and Technology (IMaST)* program is centered around the topics of biotechnology, manufacturing, and forecasting. Each unit includes objectives, experiential learning, appropriate use of multimedia, and appropriate technology and evaluation instruments. The materials motivate students, especially those from groups underrepresented in technological careers, to learn the foundation concepts of mathematics, science, and technology by involving them in enriched learning experiences relevant to their daily lives. The materials are designed to be used by mathematics, science, and technology teachers concurrently over a nine-week school session. Assessment activities designed for mathematics, science, and technology are included. Though some content areas are not addressed, there is generally excellent content alignment with the *National Science Education Standards (NSES).*

Materials Reviewed: Seventh-grade materials were reviewed. The eighth-grade materials are under development.

Strengths:

1. The materials and activities apply a hands-on approach.
2. The content and activities in science, mathematics, and technology are integrated and there is a well-represented progression of ideas and skills. The technology and science content is current.
3. The program provides teacher materials and activities as a basis for an integrative approach to learning.

General Concerns:

1. The program's activities and approaches are somewhat prescriptive.
2. It is not clear that there is sufficient attention to activities for students with high potential in science, mathematics, and/or technology.
3. The format of the program is not teacher friendly.
4. Implementation of the program may be difficult. The design of the program—three teachers teaching the program concurrently—may not fit into the schedule of some schools.

Single-Year Comprehensive

Title: *Event-Based Science: Earth Science*
Contact: Russell Wright
Montgomery County Public Schools
850 Hungerford Drive
Rockville, MD 20850
Publisher: Addison-Wesley Publishing Co.
Route 128
Reading, MA 01867
1 (800) 552-2259

The materials in *Event-Based Science: Earth Science* (EBS) provide a year-long, event-based science curriculum for heterogeneously grouped middle school students in grades 6-9 for use primarily in departmentalized earth science classes. *EBS* is different from other approaches to science instruction and curriculum writing. The event focus (e.g., earthquakes, volcanoes, tornadoes) makes each unit topical and relevant to early adolescents. It allows science to become less compartmentalized. It allows for a natural highlighting of non-traditional roles filled by women and minorities. High-interest activities are models for other activities. The approach taken by *EBS* requires students to explore other sources of information (biographies, newspapers) in order to complete class assignments. *EBS* stresses alternative assessment techniques and grading strategies that reward success and downplay failure. Nationally disseminated products include a textbook, a teacher's resource notebook, and videotape and/or videodisc support.

Materials Reviewed: All current modules and two pilot test modules were reviewed.

Strengths:

1. The materials have a strong inquiry focus.
2. The materials are highly student centered with relevant tasks.
3. There are good uses of authentic assessment.
4. The modules are interchangeable.

General Concerns:

1. There are a limited number of science activities.
2. The content of the videos could be more content-rich, but the current "hook" they provide is well done.
3. Some pilot test modules contain content errors and are not generally as engaging as the earlier work.

Single-Year Comprehensive

Title:	*Science Education for Public Understanding Program (SEPUP): Issues-Oriented Science for Secondary Schools*
Contact:	Herbert D. Their, University of California, Berkeley
Publisher:	LAB-AIDS, Inc. 17 Colt Court Ronkonkoma, NY 11779 (516) 737-1133

The *Science Education for Public Understanding Program (SEPUP)* materials support two one- year courses of study: a concrete course for middle school and a course emphasizing global issues for high school. The courses stress issue-oriented science and the use of scientific evidence and risk-benefit analysis in making decisions. These courses continue the emphasis of the *Chemical Education for Public Understanding Program (CEPUP),* societal issues involving the use of chemicals, and expand the scope of dealing with other issues of life, earth and physical sciences, and technology. Eight modules cover many of the large themes of science proposed in The American Association for the Advancement of Science's Project 2061 along with issue-oriented themes such as evidence-based decision making, uncertainty and controversy, and science and societal systems. Materials include a teacher's resource book, a student text, projects and extension activities, kits, videotapes, and software. Assessment of student learning is built into these materials. Note: A set of life science modules for *SEPUP* is now under development.

Materials Reviewed: All four sections of *Issues, Evidence, and You* were reviewed.

Strengths:

1. The materials are engaging, provide good activities for student decision making, and offer opportunities for student-designed inquiry.
2. The scope and sequence allow for conceptual growth.
3. There is an excellent assessment component.

General Concerns:

1. Materials cannot be used as a "full" curriculum; additions are needed in the areas of life and earth science.
2. There is limited use of educational technology.

Single-Year Comprehensive

Title: *Chemical Education for Public Understanding Project*
Contact: Herbert D. Their, University of California, Berkeley
Publisher: LAB-AIDS, Inc.
17 Colt Court
Ronkonkoma, NY 11779
(516) 737-1133

The *Chemical Education for Public Understanding Project (CEPUP)* at the Lawrence Hall of Science has developed 12 modular sets of interdisciplinary materials for use at the middle/junior high school level that can comprise a one-year course. The content is up-to-date, is accurate, and gives students opportunities to study materials in depth through active application of concepts. The materials introduce students to scientific concepts in chemistry and their interaction with people and the environment. *CEPUP* materials highlight areas of direct societal concerns associated with science and technology. Students are given chemistry-based laboratory investigations and experiments that focus on the environment, biotechnologies, industrial processes, agricultural practices, alternative energy sources, and health science.

Materials Reviewed: The *Teacher's Guide*, including student sheets, and *Guide for Implementation* were reviewed. All 12 of the modules were examined.

Strengths:

1. The materials address real-life issues and give students multiple opportunities to apply chemistry.
2. The focus on interdisciplinary topics is one that many middle school teachers and students will find appealing.
3. The modular format is a strength.
4. These materials help students to develop good data skills.

General Concerns:

1. The classroom assessments emphasize written tests; many potential alternative assessments are not developed.
4. The materials emphasize scientific processes and do not sufficiently emphasize scientific theory and models.

Single-Year Comprehensive

Title: *Junior High/Middle School Life Science Program*
Contact: Harold Pratt, Jefferson County Public Schools
Publisher: Kendall/Hunt Publishing Co.
4050 Westmark Drive
P.O. Box 1840
Dubuque, IA 52004
1 (800) 258-5622

The Jefferson County, Colorado Public School System developed materials that constitute a year-long junior high/middle school program in life science that emphasizes the understanding and care of the human body. The development was done in close cooperation with the University of Colorado Health Sciences Center and with the support of local physicians and university-level scientists and science educators. The program provides an alternative for teachers and schools seeking materials to improve their life science curriculum and serves as a resource for schools seeking to integrate health topics with their existing life science course. General topics included in the materials are life science, human biology and reproduction, ecology, cells, and genetics. The life science section, although only in the context of human biology, aligns well with the *National Science Education Standards (NSES).* Part of the program directs students toward an ability to make decisions in and about their local environment. Materials include student text and investigations, an extensive *Teachers' Guide,* the *Teachers' Resource Book* (which includes transparency masters, worksheets, etc.), and the *Guide for Implementation.*

Materials Reviewed: The student text and investigations, *Teacher's Guide, Teacher's Resource Book,* and the *Guide for Implementation* were reviewed.

Strengths:

1. The materials contain a strong activity orientation, and many students will find them engaging.
2. The materials explicitly help students move from the big picture to smaller ideas.
3. The materials provide good teacher support.
4. The health-related topics contain sensitive treatment of key issues in language appropriate for middle school students.

General Concerns:

1. The materials are weak in the area of student assessments.
2. Students are not encouraged to design their own investigations.
3. This curriculum is overstuffed—there is more material presented than students can reasonably learn, and much of it focuses on facts and vocabulary.

Supplemental Technology Driven

Title:	*National Geographic Kids Network*
Contact:	Daniel Barstow, TERC, Inc.
Publisher:	National Geographic Society Educational Services Department 89 Washington, DC 20036 1 (800) 368-2728

These materials extend those developed for grades 4-6 with nine units (or approximately 90 weeks) of supplementary science material targeted for grades 7-9 and organized around telecommunications-based collaborative student research. The materials contain coordinated curriculum and software and were designed by TERC in collaboration with the National Geographic Society (NGS). Each unit requires students to gather data, share these data with students in other school districts over a telecommunications network, and analyze the collected data. This approach allows students to perform like scientists. Before gathering the data, students study the underlying science content and learn the experimental skills required to perform appropriate measurements. Following data collection, students apply data analysis techniques and reflect on the social significance of the problem addressed in the study. Study areas proposed include Conditions for Growth, Trees, Student Fitness, Acid Deposition, Recycling and Composting, Radon, Alternative Energy Sources, Automobile Accidents, and Greenhouse Gases. The materials include a teacher's guide, readings, student lab sheets, assessments, overhead transparencies, posters, works and reference disks, and a *Quick Guide to Using NGS Works.*

Materials Reviewed: The unit "What Is Our Soil Good For?" was reviewed.

Strengths:

1. Technology is used well as a tool in these materials.
2. There is good focus on science as inquiry.
3. The data collection/analysis activities are strong.
4. The materials permit students to explore science experiences in depth.

General Concerns:

1. The materials are expensive, the software is complicated, and difficulties can be anticipated in its use.
2. The technology is not used to its full potential. There is a lack of graphics, the menus are tedious, and data analysis tools are weak.
3. These materials do not compose a full-year program.

THE PROJECT 2061 CURRICULUM-ANALYSIS PROCEDURE

INTRODUCTION

Deciding which curriculum materials to use is one of the most important professional judgments that educators make. Textbook adoption committees make recommendations that influence instruction for years to come, and the daily decisions teachers make about which teaching units or chapters to use—and how to use them—largely determine what and how students will be expected to learn.

Such important decisions require a valid and reliable method for evaluating the quality of curriculum materials. Even an in-depth review of the topics covered by a textbook or a teaching unit may not be sufficient to determine whether the material will actually help students learn that content. What is needed is a manageable process for examining curriculum materials that gets below the surface by focusing intensely on the *appropriateness of content* and the *utility of instructional design.*

With funding from the National Science Foundation and in collaboration with hundreds of K-12 teachers, curriculum specialists, teacher educators, scientists, and materials developers, Project 2061 of the American Association for the Advancement of Science (AAAS) has been developing a process for analyzing curriculum materials. Field tests suggest that Project 2061's curriculum-analysis procedure will not only serve the materials adoption needs of the schools but also help teachers revise existing materials to increase their effectiveness, guide developers in the creation of new materials, and contribute to the professional development of those who use it.

SPECIFIC LEARNING GOALS ARE KEY

Until recently, there was nothing against which to judge appropriateness of content and utility of instructional design. Now, as a result of the standards-based reform movement in education, these judgments can be made with a high degree of confidence. In science and mathematics, for example, the appearance of *Science for All Americans* (AAAS, 1989), *Curriculum and Evaluation Standards for School Mathematics* (National Council of Teachers of Mathematics, 1989), *Benchmarks for Science Literacy* (AAAS, 1993), and *National*

Science Education Standards (National Research Council, 1996) has made it possible to make more thoughtful decisions about curriculum materials than ever before.

Although the Project 2061 curriculum-analysis procedure was developed using the learning goals in *Benchmarks* and the mathematics and science standards, subsequent work has indicated that some state education frameworks also can be used. Indeed, the process would seem to apply to any K-12 school subject for which specific learning goals have been agreed upon. These goals must be explicit statements of what knowledge and skills students are expected to learn, and they must be precise. Vague statements such as "students should understand energy" are not adequate. Instead, consider this benchmark dealing with energy-related concepts that students should know by the end of the eighth grade:

> *Most of what goes on in the universe—from exploding stars and biological growth to the operation of machines and the motion of people—involves some form of energy being transformed into another. Energy in the form of heat is almost always one of the products of an energy transformation.*

Similar explicit statements can be found in the fundamental concepts of the National Research Council's *National Science Education Standards (NSES).*

At its simplest level, the Project 2061 curriculum-analysis procedure involves the following five steps:

- **Identify specific learning goals to serve as the intellectual basis for the analysis.** This is done before beginning to examine any curriculum materials. The source for appropriate goals can be national standards or benchmark documents such as those mentioned above, state or local standards and curriculum frameworks, or sources like them. To be useful, the goals must be precise in describing the knowledge or skills they intend students to have. If the set of goals is large, a representative sample of them should be selected for purposes of analysis.
- **Make a preliminary inspection of the curriculum materials to see whether they are likely to address the targeted learning goals.** If there appears to be little or no correspondence, the materials can be rejected without further analysis. If the outlook is more positive, go on to a content analysis.

- **Analyze the curriculum materials for alignment between content and the selected learning goals**. The purpose here is to determine, citing evidence from the materials, whether the content in the material matches specific learning goals—not just whether the topic headings are similar. At the topic level, alignment is never difficult, since most topics—heredity, weather, magnetism, and so forth—lack specificity, making them easy to match. If the results of this analysis are positive, then reviewers can take the next step.
- **Analyze the curriculum materials for alignment between instruction and the selected learning goals**. This involves estimating the degree to which the materials (including their accompanying teacher's guides) reflect what is known generally about student learning and effective teaching and, more important, the degree to which they support student learning of the *specific knowledge and skills for which a content match has been found.* Again, evidence from the materials must be shown.
- **Summarize the relationship between the curriculum materials being evaluated and the selected learning goals.** The summary can take the form of a profile of the selected goals in terms of the content and instruction criteria, or a profile of the criteria in terms of the selected goals. In either case, a statement of strengths and weaknesses should be included. With this information in hand, reviewers can make more knowledgeable adoption decisions and suggest ways for improving the examined materials.

In addition to its careful focus on matching content and instruction to very specific learning goals, the Project 2061 procedure has other features that set it apart. For example, its emphasis on collecting explicit evidence (citing page numbers and other references) of a material's alignment with learning goals adds rigor and reliability to decisions about curriculum materials. Similarly, the Project 2061 procedure calls for a team approach to the analytical task, thus providing opportunities for reviewers to defend their own judgments about materials and to question those of other reviewers. These and other characteristics help make participation in the analytical process itself a powerful professional development experience.

THE PROJECT 2061 CURRICULUM-ANALYSIS PROCEDURE IN DETAIL

To provide a better sense of how the procedure works, the following describes in more detail each step in the procedure, using learning goals from Project 2061's *Benchmarks for Science Literacy* as an illustrative frame of reference. The description pays particular attention to the various criteria used to evaluate the instructional effectiveness of materials.

Identify specific learning goals to serve as the intellectual basis for the analysis. After reviewers have agreed upon a set of learning goals as a framework for the analysis (in this case, the benchmarks in *Benchmarks for Science Literacy*), the task is then to choose specific benchmarks that will serve as the focus of further study.

When evaluating standalone curriculum units that cover a relatively short period of time, it might be possible and worthwhile to analyze *all* of the benchmarks that appear to be targeted by the material. However, in the evaluation of year-long courses or multiyear programs, this becomes impractical. Therefore, a crucial step in the analysis procedure is the sampling of a few benchmarks that will lead to valid and reliable generalizations about the material.

Sampling of benchmarks should be representative of the whole set of goals specified in *Benchmarks for Science Literacy* and should reflect the reviewers' needs. For example, if the review committee's task is to select a course in high school Biology that is aligned with *Benchmarks*, it might identify a sample of benchmarks from life science sections in *Benchmarks* (e.g., cells, heredity, and evolution) and from other sections (e.g., nature of scientific inquiry, models, and communication skills). When examining middle-school science materials, one would probably want to broaden the range of benchmarks examined to include some from physical and earth science topics (e.g., energy, forces, and processes that shape the earth).

Make a preliminary inspection of the curriculum materials to see whether they are likely to address the targeted learning goals. Once benchmarks have been selected, the next step is to make a first pass at the materials to identify those whose content appears to correspond reasonably well to *Benchmarks*. Materials that do not meet these initial criteria are not analyzed further.

Reviewers then examine materials on the shortened list more carefully to locate and record places where each selected benchmark seems to be targeted (e.g., particular readings, experiments, discussion questions). If several sightings are found for some or all of the sample benchmarks in the material, then these sightings will be looked at more carefully in subsequent steps of the analysis. If, on the other hand, sightings cannot be found for a significant number of the sample benchmarks, then the material is dropped from the list.

Analyze the curriculum materials for alignment between content and the selected learning goals. This analysis is a more rigorous examination of the link between the subject material and the selected learning goals and involves giving precise attention to both ends of the match—the precise meaning of the benchmark on one end and the precise intention of the material on the other.

With respect to each of the sampled benchmarks, the material is examined using such questions as:

- Does the content called for in the material address the substance of a specific benchmark or only the benchmark's general "topic"?
- Does the content reflect the level of sophistication of the specific benchmark, or are the activities more appropriate for targeting benchmarks at an earlier or later grade level?
- Does the content address all parts of a specific benchmark or only some? (While it is not necessary that any particular unit would address all of the ideas in a benchmark or standard, the K-12 curriculum as a whole should do so. The purpose of this question is to provide an account of precisely what ideas are treated.)

In addition, an attempt is made to estimate the degree of overlap between the material's content and the set of benchmarks of interest. Thus, this step in the analysis is designed to answer questions regarding the material's inclusion of content that is not required for reaching science literacy and the extent to which the material distinguishes between essential and non-essential content. (While distinguishing content essential for literacy from non-essential content in material might seem to be a luxury, it assists teachers in determining the range of students for which the material can be used. Identifying the non-essential material makes it easier for the teacher to direct better students to enrichment activities and allows students themselves to avoid overload from ideas that go beyond what is vital.)

Analyze the curriculum materials for alignment between instruction and the selected learning goals. The purpose here is to estimate how well material addresses targeted benchmarks from the perspective of what is known about student learning and effective teaching. The criteria for making the judgments in the instructional analysis are derived from research on learning and teaching and on the craft knowledge of experienced educators. In the context of science literacy, these are summarized in Chapter 13, "Effective Learning and Teaching," of *Science for All Americans*; in Chapter 15, "The Research Base," of *Benchmarks for Science Literacy*; and in Chapter 3, "Science Teaching Standards," of *National Science Education Standards*.

From these sources, seven criteria clusters (shown below) have been identified to serve as a basis for the instructional analysis (for the specific questions within each cluster, see Appendix on page 137). The proposition here is that (1) the analysis would tie the instruction to each one of the sample benchmarks rather than look at instructional strategies globally and (2) in the ideal, *all* questions within each cluster would be well-addressed in any material—they are not alternatives.

Cluster I. Providing a Sense of Purpose: Part of planning a coherent curriculum involves deciding on its purposes and on which learning experiences will likely contribute to those purposes. But while coherence from the curriculum designers' point of view is important, it may not give students an adequate sense of what they are doing and why. This cluster includes criteria to determine whether the material attempts to make its purposes explicit and meaningful to students, either by itself or by instructions to the teacher.

Cluster II. Taking Account of Student Ideas: Fostering better understanding in students requires taking time to attend to the ideas they already have, both ideas that are incorrect and ideas that can serve as a foundation for subsequent learning. Such attention requires that teachers be informed about prerequisite ideas/skills needed for understanding a benchmark and what their students' initial ideas are∫in particular, the ideas that may interfere with learning the scientific information. Moreover, teachers can help address students' ideas if they know what is likely to work. This cluster examines whether the material contains specific suggestions for identifying and relating to student ideas.

Cluster III. Engaging Students with Phenomena: Much of the point of science is explaining phenomena in terms of a small number of principles or ideas. For students to appreciate this explanatory power, they need to have a sense of the range of phenomena that science can explain. "Students need to get acquainted with the things around them—including devices, organisms, materials, shapes, and numbers—and to observe them, collect them, handle them, describe them, become puzzled by them, ask questions about them, argue about them, and then try to find answers to their questions." (*Science for All Americans*, p. 201) Furthermore, students should see that the need to explain comes up in a variety of contexts.

Cluster IV. Developing and Using Scientific Ideas: *Science for All Americans* includes in its definition of science literacy a number of important yet quite abstract ideas (e.g., atomic structure, natural selection, modifiability of science, interacting systems, common laws of motion for earth and heavens). Such ideas cannot be inferred directly from phenomena, and the ideas themselves were developed over many hundreds of years as a result of considerable discussion and debate about the cogency of theory and its relationship to collected evidence. Science literacy requires that students see the link between phenomena and ideas and see the ideas themselves as useful. This cluster includes criteria to determine whether the material attempts to provide links between phenomena and ideas and to demonstrate the usefulness of the ideas in varied contexts.

Cluster V. Promoting Student Reflection: No matter how clearly materials may present ideas, students (like all people) will assign their own meanings to them. Constructing meaning well is aided by having students (1) make their ideas and reasoning explicit, (2) hold them up to scrutiny, and (3) recast them as needed. This cluster includes criteria for determining whether the material suggests how to help students express, think about, and reshape their ideas to make better sense of the world.

Cluster VI. Assessing Progress: There are several important reasons for monitoring student progress toward specific learning goals. Having a collection of alternatives can ease the creative burden on teachers and increase the time available to analyze student responses and make adjustments in instruction based on those responses. This cluster includes criteria for evaluating whether the material includes a variety of goal-relevant assessments.

Cluster VII. Enhancing the Learning Environment: Many other important considerations are involved in the selection of curriculum materials—for example, the help they provide to teachers in encouraging student curiosity and creating a classroom community where all can succeed, or the material's scientific accuracy or attractiveness. The criteria listed in this cluster provide reviewers with the opportunity to comment on these and other important features.

Summarize the relationship between the curriculum materials being evaluated and the selected learning goals. In the preliminary inspection, a few benchmarks were selected as representative of the set of goals that the material appears to target. Having analyzed whether the content in the material matches these specific benchmarks and how well the instructional strategies in the material support students learning these benchmarks, the final step in the process is to provide a profile of the material based on this analysis.

The analysis makes it possible to produce two sets of profiles. The first illustrates how well the material treats *each* benchmark (for which a content match was found) across all criteria examined in the instructional analysis. Based on these profiles, conclusions can be made about what the material under consideration can be expected to accomplish in terms of benchmarks. For example, the profiles may indicate that the material treats one of the examined benchmarks well and the rest only moderately or poorly.

The second set of profiles illustrates how well the material meets each *criterion* in the instructional analysis tool across all benchmarks examined. These profiles point to major strengths and weaknesses in the instructional design of the material. For example, the profiles may indicate that the material consistently includes appropriate experiences with phenomena relevant to the benchmarks but only occasionally provides students with opportunities to reflect on these experiences. Depending on the time available and their interests, a review committee could decide to produce either one or both sets of profiles. Profiles of different materials provide the basis for selection decisions.

Support for Users

Project 2061 is in the process of developing "Resources for Science Literacy: Curriculum Evaluation," a CD-ROM that will offer full instruction in using the procedure. The CD-ROM and its print companion volume will contain (1) detailed instructions for evaluating curriculum materials in light of *Benchmarks*, national standards, or other learning goals of comparable specificity; (2) case-study reports illustrating the application of the analysis procedure to a variety of curriculum materials; (3) a utility for relating findings in the case-study reports to state and district learning goals; and (4) a discussion of issues and implications of using the procedure.

Project 2061 also offers introductory workshops and longer training institutes to groups of educators. Typically three to six days long, the training institutes can be adapted to suit a variety of needs and time constraints. The project has offered customized workshops for K-12 science and mathematics teachers, teacher educators, school and university administrators, developers of curriculum materials, and policy makers. Depending on the interests of participants, the workshops can focus on understanding learning goals, selecting materials, revising existing materials, or evaluating curriculum frameworks, among other possibilities.

For information on Project 2061's workshops and institutes (or any aspects of Project 2061's work) contact Mary Koppal, Project 2061, American Association for the Advancement of Science (see the Guide to Using the Methods of Analysis section of this *Guidebook* for contact information).

PUTTING THE PROJECT 2061 CURRICULUM-ANALYSIS PROCEDURE TO WORK

Many of the educators involved in developing and field testing the Project 2061 procedure have begun to use it to decide on materials for their classrooms, school districts, or states; to identify shortcomings in materials they are using; and to suggest ways to improve them. Here are a few examples of how educators have adapted the procedure to their local needs and time constraints:

San Antonio. Faced with the task of selecting a new high-school physical science textbook from five possible choices, a San Antonio school district committee requested training in the Project 2061 curriculum-analysis procedure. Already familiar with *Benchmarks for Science Literacy* and *Science for All Americans*, these 12 educators spent two days studying Project 2061's analytical criteria, as well as some additional criteria decided locally. Committee members then evaluated one material apiece, with at least two committee members independently evaluating each material. When finished with their independent evaluations, those educators reviewing the same material met to compare their results and to come to an agreement about the value of the material. Then, about three weeks after the initial training, the whole group reconvened to share their results and settle on the material. Because the evaluation procedure requires reviewers to cite evidence for judgments made, the reviewers were prepared to justify their recommendations, pointing to specific instructional strategies for particular learning goals in physical science.

After much discussion, the reviewers reached agreement on one material for the district. Throughout the process, the reviewers were very reflective and motivated by the work at hand. In fact, because the evaluation procedure had revealed some weaknesses even in the material they agreed to select, they decided to write a supplemental unit on one topic.

Philadelphia. The Philadelphia school district was already committed to teaching toward specific learning goals derived from *Benchmarks* and *National Science Education Standards* when it set out to identify materials that are aligned with those goals. Their list of possibilities included some materials developed through National Science Foundation funding and some materials that had been favorably evaluated by the Project 2061 pilot and field test participants. The district held training institutes to introduce teachers to the evaluation procedure and to develop evaluation skills that they would use to select materials from the list of possibilities. More than 200 teachers participated in the institutes, giving the district a cadre of leaders who could assist in the school-based selection of curriculum materials.

After employing the procedure to select materials for use in their classrooms, teachers planned to make a more thorough evaluation of the materials when they eventually put them to use. Findings from the procedure also will be used to improve materials currently being implemented in district classrooms. Such remedies might include developing questions to focus students' reflection on benchmark ideas, adding activities to address student learning difficulties, or demonstrating how benchmark ideas are useful for making sense of the students' world outside the classroom.

Through its work with the Project 2061 procedure, Philadelphia has developed a group of educators who are becoming more knowledgeable about specific learning goals in *Benchmarks* and the *National Science Education Standards* and about the analysis criteria used to judge materials in light of these goals. As new, better aligned materials become available, the district will have a cadre of informed consumers who can recognize them and put them to work. Most important, district classrooms will reflect teaching and learning that engage all students in achieving science literacy goals essential for the 21st century.

Kentucky. In the fall of 1996, Project 2061 began to work with the director of the Kentucky Middle Grades Mathematics Teacher Network to adapt the project's curriculum analysis procedure to mathematics. The Kentucky Network, which already reaches some

2,000 teachers, aims to align the state's mathematics content and teaching practices in fifth through eighth grades with the recommendations of the National Council of Teachers of Mathematics' *Curriculum and Evaluation Standards for School Mathematics.* In particular, the network helps to train teachers in reviewing and analyzing curriculum materials so that they can (1) discriminate between materials that only claim to align with the mathematics standards and those that actually do and (2) recognize standards in the newer, integrated mathematics curricula.

As the criterion for alignment, Project 2061 has used Kentucky's *Mathematics Core Content for Assessment* (which elaborates the national mathematics standards into more specific goal statements) to analyze five middle-school curriculum projects funded by the National Science Foundation (NSF). While developing the analysis procedure and applying it to the materials, Project 2061 received continual feedback from Kentucky teachers and from a national advisory committee that included the developers of the NSF-funded curricula.

During a 1997 two-week summer workshop, 32 Kentucky teachers used the analysis procedure and case-study reports to examine middle-grade mathematics materials and develop workshops for teachers throughout the state. In doing so they (1) gained a better understanding of integrated, problem-based mathematics curricula; (2) developed the skills necessary to evaluate mathematics curricula in light of specific learning goals; and (3) developed skills necessary to effectively share what they have learned throughout their regions. The workshop participants worked during the 1997-1998 school year with teachers, schools, and districts in their regions to assist in analyzing and evaluating mathematics curriculum materials.

APPENDIX
Criteria for Instructional Analysis

Project 2061's curriculum-analysis procedure uses the following questions, grouped within seven criteria clusters, to determine the extent to which the material's instructional strategy is likely to help students learn the content.

Cluster I. Providing a Sense of Purpose:

Framing. Does the material begin with important focus problems, issues, or questions about phenomena that are interesting and/or familiar to students?

Connected sequence. Does the material involve students in a connected sequence of activities (vs. a collection of activities) that build toward understanding of the benchmark(s)?

Fit of frame and sequence. If there is both a frame and a connected sequence, does the sequence follow well from the frame?

Activity purpose. Does the material prompt *teachers* to convey the purpose of an activity and its relationship to the benchmarks? Does each activity encourage *each student* to think about the purpose of the activity and its relationship to specific learning goals?

Cluster II. Taking Account of Student Ideas:

Identifying prerequisite knowledge/skills. Does the material specify prerequisite knowledge/skills that are necessary to learn the benchmark(s)?

Alerting to commonly held ideas. Does the material alert teachers to commonly held student ideas (both troublesome and helpful) such as those described in *Benchmarks,* Chapter 15, "The Research Base"?

Assisting the teacher in identifying students' ideas. Does the material include suggestions for teachers to find out what *their* students think about familiar phenomena related to a benchmark before the scientific ideas are introduced?

Addressing commonly held ideas. Does the material explicitly address commonly held student ideas?

Assisting the teacher in addressing identified students' ideas. Does the material include suggestions for teachers on how to address ideas that their students hold?

Cluster III. Engaging Students with Phenomena:

Firsthand experiences. Does the material include activities that provide firsthand experiences with phenomena relevant to the benchmark when practical and, when not practical, make use of videos, pictures, models, simulations, and so forth?

Variety of contexts. Does the material promote experiences in multiple contexts so as to support the formation of generalizations?

Questions before answers. Does the material link problems or questions about phenomena to solutions or ideas?

Cluster IV. Developing and Using Scientific Ideas:

Building a case. Does the material suggest ways to help students draw from their experiences with phenomena, readings, activities, and so forth to develop an evidence-based argument for benchmark *ideas*? (This could include reading material that develops a case.)

Introducing terms. Does the material introduce technical terms only in conjunction with experience with the idea or process and only as needed to facilitate thinking and promote effective communication?

Representing ideas. Does the material include appropriate representations of scientific ideas?

Connecting ideas. Does the material explicitly draw attention to appropriate connections among benchmark ideas (e.g., to a concrete example or an instance of a principle or generalization, to an analogous idea, or to an idea that shows up in another field)?

Demonstrating/modeling skills and use of knowledge. Does the material demonstrate/model or include suggestions for teachers on how to demonstrate/model skills or the *use* of knowledge?

Encouraging practice. Does the material provide tasks/questions for students to continue practicing skills or *using* knowledge in a variety of situations?

Cluster V. Promoting Student Reflection:

Expressing ideas. Does the material routinely include suggestions (such as group work or journal writing) for having each student express, clarify, justify, and represent his or her ideas? Are suggestions made for when and how students will get feedback from peers and the teacher?

Reflecting on activities. Does the material include tasks and/or question sequences to guide student interpretation and reasoning about phenomena and activities?

Reflecting on when to use knowledge and skills. Does the material help or include suggestions on how to help students know when to use knowledge and skills in new situations?

Self-monitoring. Does the material suggest ways to have students check their own progress and consider how their ideas have changed and why?

Cluster VI. Assessing Progress:

Alignment to goals. Assuming a content match of the curriculum material to this benchmark, are assessment items included that match the content?

Application. Does the material include assessment tasks that require application of ideas and avoid allowing students a trivial way out, like using a formula or repeating a memorized term without understanding?

Embedded. Are some assessments embedded in the curriculum along the way, with advice to teachers as to how they might use the results to choose or modify activities?

Cluster VII. Enhancing the Learning Environment:

Teacher content learning. Would the material help teachers improve their understanding of science, mathematics, and technology, as well as their interconnections?

Classroom environment. Does the material help teachers to create a classroom environment that welcomes student curiosity, rewards creativity, encourages a spirit of healthy questioning, and avoids dogmatism?

Encouragement for all students. Does the material help teachers to create a classroom community that encourages high expectations for all students, that enables all students to experience success, and that provides different kinds of students with a feeling of belonging in the science classroom?

Connections beyond the unit. Does the material explicitly draw attention to appropriate connections to ideas in other units?

Other strengths. What, if any, other features of the material are worth noting?

California Department of Education Curriculum Frameworks and Instructional Resources

K-8 Mathematics Instructional Resources Evaluation Form

(Approved by the State Board of Education on April 11, 1996)

This evaluation form will be used by the Instructional Resources Evaluation Panel (IREP) as they review K-8 resources. The criteria are based on Appendix A of the *Mathematics Framework for California Public Schools, Kindergarten Through Grade Twelve,* approved by the State Board of Education on November 8, 1991, and are designed to be used with complete programs (at least a full grade level). This form is different from the evaluation form used for the 1994 primary adoption. It has been revised to include the importance of a "...mathematics program that reflects a balance of basic skills, conceptual understanding, and problem solving." The concept of the "balanced program" has been added to the following categories: (1) Mathematical Content; (2) The Work Students Do; (3) Program Organization and Structure; and (4) Assessment.

The criteria are organized into the following categories. The percent that each category contributes to the overall score is listed in parentheses.

- **Mathematical Content:** Which mathematical ideas and subject matter provide the basis for the instructional program. (20%)
- **Program Organization and Structure:** How the program is organized into a year's work of cohesive units, lessons, and tasks. (15%)
- **The Work Students Do:** What the students work on and how they do it. (25%)
- **Student Diversity:** How the program deals with diverse cultural and economic backgrounds, achievement levels, English language proficiencies, and interests of students. (10%)
- **Assessments:** How the program integrates assessment with instruction, and how the program helps teachers assess student performance. (10%)
- **Support for the Teacher:** How the resources support what the teacher does in the classroom. (20%)

Each category offers a different perspective of how the total program is intended to be experienced by the students. In using these categories, reviewers should keep in mind the following general points:

- These categories are not distinct; they overlap. For example, students' experiences in a program cannot be judged simply by looking at the category, "The Work Students Do." Their experiences will also be affected by the role of the teacher, by the kinds of units and tasks that students work on, and by the mathematical content of the program.
- In each category, all of the components of an instructional program (such as student resources, teacher resources, and technology) are to be examined in terms of how they work together to provide a quality program for students in a classroom. These criteria do not presuppose the presence or absence of any particular component. It is possible to design a complete program that does not have a single student text, and it is possible to design a high-quality program that does have a student text at its center. Similarly, videotapes, computer software, and other technology might or might not be included in a program.
- Each category is described by a few paragraphs. These paragraphs and the subpoints within them are not necessarily of equal weight. They should not be judged individually. Rather, they should be used as an aid to identifying the qualities that contribute to a category.
- Instructional resources need to be descriptive enough to help conscientious teachers implement a new kind of program, yet not so tightly structured that teachers have little flexibility in their implementation.
- In applying these criteria, reviewers will take into account appropriateness for particular grade levels.

A rating, ranging from 0 to 5, is made for each category. Paragraph descriptions of "5," "3.5," and "1" ratings are provided in this evaluation form to assist the reviewer. A weighted score of 70 out of a possible 100 (average rating 3.5) will be required for IREP recommendation for adoption.

The following notes supplement the tables that follow:

* The strands as defined in the *Mathematics Framework* (logic and language, geometry, functions, discrete mathematics, measurement, number and operation, algebra, and statistics and probability) and the *Curriculum and Evaluation Standards for School Mathematics* of the National Council of Teachers of Mathematics, are specified by grade spans, not by grade levels. The levels of analysis will be at those of the 13 standards, for which the bullets serve as exemplars of what the standards look like in that span. It is permissible to introduce an idea from a later span at an earlier time and to continue to study an idea from an earlier span at a later time. It is also permissible to include ideas that are not specifically mentioned in the *Standards.*

** Definition of "all three areas":

- **Basic Skills** are those skills that every student needs to be able to use mathematics and solve problems. Basic skills are not only part of the number and operation strand, but are also part of all other strands. For example, students need to know: number facts, how to find correct answers to addition, subtraction, multiplication, and division problems; fractions, decimal, and percent equivalencies; how to measure; correct terms for geometric shapes; how to read graphs of data; and how to solve equations.
- **Conceptual understanding** means that students make sense of the mathematics operations they perform. They not only know *how* to apply skills but also *when* to apply them and *why* they are being applied. Conceptual understanding provides students with the basis for seeing the relationships between skills and problem solving and among mathematical ideas. Students with conceptual understanding see the structure and logic of mathematics, use mathematics more flexibly and appropriately, and are able to recall or adapt rules because they see the larger pattern.
- **Problem solving** requires the use of mathematical reasoning—analyzing the situation, thinking about approaches that are reasonable, considering appropriate methods to find a solution, and determining how to verify that results make sense in the context of the original situation. Solving a problem involves applying mathematical skills, understandings, and experiences to resolve new or perplexing situations.

Evaluation Table: Mathematical Content

Mathematical Content (5)	Mathematical Content (3.5)	Mathematical Content (1)
The program reflects a balance of basic skills, conceptual understanding, and problem solving, within the eight strands* included in the 1992 Mathematics Framework.	Most of the program reflects a balance of basic skills, conceptual understanding, and problem solving, within the eight strands* included in the 1992 *Mathematics Framework*.	The program does not reflect a balance of basic skills, conceptual understanding, and problem solving, within the eight strands* included in the 1992 *Mathematics Framework*.
At each grade level, all three areas** (basic skills, conceptual understanding, and problem solving) are emphasized; none is neglected nor deemphasized more than another, and overall, the program reinforces the relationships among the areas.	At each grade level, all three areas** (basic skills, conceptual understanding, and problem solving) are included, although one area may be emphasized more than the others. Frequently, lessons include all three areas, and overall, the program reinforces the relationships among the areas.	At some grade levels, one of the three areas** (basic skills, conceptual understanding, and problem solving) may be omitted, and/or one area may be emphasized at the exclusion of the others. Frequently, lessons address only one of the three areas.
At each grade level, basic skills, conceptual understanding, and problem solving are developed in most, if not all, of the strands,* and all of the strands are developed in each grade span. Most, if not all, of the strands* are developed in each year's program. Overall, the units of instruction interweave ideas from more than one strand. The unifying ideas are fully explored over the course of a given year. The mathematical subject matter is coherent.	At each grade level, basic skills, conceptual understanding, and problem solving are developed in most of the strands,* and most of the strands are developed in each grade span. Most of the strands* are developed in each year's program. More than half of the units of instruction interweave ideas from more than one strand, while others concentrate on a single strand. The unifying ideas are explored over the course of a given year, though a few may be given limited attention. The mathematical subject matter in a few of the units fails to meet the criteria of coherence.	Some of the strands* are ignored or treated superficially in each year's program. Units of instruction typically treat one strand independent of the others. The unifying ideas are treated superficially, if at all. The mathematical subject matter is fragmented and fails to achieve coherence.
"Number sense" is usually developed in realistic contexts, and students nearly always produce numerical results for a purpose. Students have ample opportunities to devise their own procedures and are consistently expected to decide the most efficient means for calculating a numerical result in a given situation: mentally, with paper and pencil, or with a calculator. The numbers in problems are nearly always realistic, and problems in upper elementary grades and beyond have rarely been contrived to keep solutions confined to integers.	More than half of the time, "number sense" is developed in realistic contexts, and students produce numerical results for a purpose. Students have regular opportunities to devise their own procedures and to decide the most efficient means for calculating a numerical result in a given situation: mentally, with paper and pencil, or with a calculator. The numbers in problems are usually realistic, and problems in upper elementary grades and beyond are usually not contrived to keep solutions confined to integers.	"Number sense" is not developed in realistic contexts; students often produce numerical results without purpose and have few opportunities to devise their own procedures. They are usually required to decide the most efficient means for calculating a numerical result in a given situation: mentally, with paper and pencil, or with a calculator. The numbers in problems are often unrealistic, and problems in upper elementary grades and beyond have often been contrived to keep solutions confined to integers.

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Evaluation Table: Program Organization and Structure

Program Organization and Structure (5)	Program Organization and Structure (3.5)	Program Organization and Structure (1)
The instructional resources reflect a balance of basic skills, conceptual understanding, and problem solving.	Most of the instructional resources reflect a balance of basic skills, conceptual understanding, and problem solving.	The instructional resources do not reflect a balance of basic skills, conceptual understanding, and problem solving.
The instructional resources present students with coherent, connected, and accessible mathematical experiences organized into units of work lasting one to six weeks that have instructional and mathematical coherence. While a year's work may include some activities that do not belong to any unit or units that are distributed and interspersed over a period of time, most of the year's work is organized in concentrated units.	Most of the year's work consists of units that contain investigations, problems, and exercises that are related to one another, though a few of the connections may be weak. Assignments of varying length are found in most units; while there are substantial investigations in some units, others may contain only brief or introductory investigations. More often than not, units involve concepts from more than one strand.	The year's work consists of activities that are fragmented or disconnected from one another. Connections within a unit—investigations, problems, and exercises—are often weak or contrived. Assignments are frequently narrow, with a few substantial investigations and many one-day lessons. Units often focus on a single strand or set of procedures, or fail to demonstrate mathematical ideas in many settings.
Units include investigations, problems and exercises that are related to one another. Assignments vary in length. Some are relatively large and complex and may form the backbone of the unit, while others may be more limited in their scope and provide the tools or techniques for successful completion of the investigation. Lessons and tasks within a unit most often involve concepts from more than one strand and explore their interconnections and relationships. Some tasks are quantitative, interdisciplinary "real life" problems; others are more purely mathematical investigations, including games and puzzles.		
The instructional resources outline a default sequence for the units and indicate how teachers can use the program flexibly, rearranging, substituting, or modifying units and tasks to meet the needs and interests of their students. Students are given opportunities to decide which tasks to work on or in which order, such as provided in a "menu" format or alternative investigations.	The instructional resources outline a default sequence for the units, with some general suggestions of ways teachers can modify the program to meet the needs and interests of their students. Students are occasionally given opportunities to decide which tasks to work on or in which order, such as provided in a "menu" format.	The instructional resources outline a fairly rigid sequence for the units, with few suggestions of ways teachers can modify the program to meet the needs and interests of their students. Students are rarely given opportunities to decide which tasks to work on or in which order, such as provided in a "menu" format.
From year to year, the units—and the tasks within them—increase in depth and complexity. Students encounter the same unifying mathematical ideas in different or more complex context. Gradually, tasks increase in duration; tasks include more abstraction and formalism; students grapple with increasingly complex questions and investigations; and students assume more and more responsibility for developing complete and comprehensive reports or products.	From year to year, a few units may be at a level of depth similar to the previous year's, but most of the units—and the tasks within them—increase in depth and complexity and challenge students to assume increasing responsibility for developing complete reports or products.	From year to year, there is little progression in the level of depth, contexts are repetitious, and few units challenge students to assume responsibility for developing complete reports or products.

Evaluation Table: The Work Students Do

The Work Students Do (5)	The Work Students Do (3.5)	The Work Students Do (1)
Students are consistently expected to think and reason in their mathematical work, to work on a variety of challenging and meaningful mathematical tasks, and to conjecture and pursue possibilities without knowing the answer will follow. Most assignments ask for complete student work; students are asked to think and communicate, to draw on mathematical ideas, and to use mathematical tools and techniques effectively.	More often than not, students are expected to think and reason in their mathematical work, to work on a variety of challenging and meaningful mathematical tasks, and to conjecture and pursue possibilities without knowing the answer will follow. Many assignments ask for complete student work; students are asked to think and communicate, to draw on mathematical ideas, and to use mathematical tools and techniques effectively.	Only occasionally are students expected to think and reason in their mathematical work, to work on a variety of challenging and meaningful mathematical tasks, and to conjecture and pursue possibilities without knowing the answer will follow; more often students are expected to follow prescribed directions to achieve a predetermined answer. Few assignments ask for complete student work in which students are asked to think and communicate, to draw on mathematical ideas, and to use mathematical tools and techniques effectively; many assignments focus on one of the aspects of mathematical power independent of the others.
Students encounter a varied program of exercises, problems, and investigations that requires the use of a balance of basic skills, conceptual understanding, and problem solving and that includes all of the strands and unifying ideas. Most assignments are open ended and allow multiple approaches. Students are often asked to formulate mathematical questions, generally choose the approaches to take, frequently reflect on the work they are doing, and make connections among the mathematical ideas. Many tasks required time and deliberation and, especially after third grade, are continued over several days. On these extended assignments, resources help teachers set a clear standard of performance for student work and suggest ways to help students meet the standard.	All students encounter a varied program, including experience with exercises, problems, and investigations, that frequently requires the use of a balance of basic skills, conceptual understanding, and problem solving and that includes most of the strands and unifying ideas. Some assignments are open ended and allow multiple approaches. In these assignments, students are asked to formulate mathematical questions, to choose the approaches to take, to reflect on the work they are doing, and to make connections among the mathematical ideas. Many tasks require time and deliberation and, especially after third grade, are continued over at least a few days. On these extended assignments, resources help teachers set a clear standard of performance for student work and suggest ways to help students meet the standard.	Students do not encounter a varied program; some strands and unifying ideas are treated superficially, if at all, and the program does not provide experience with exercises, problems, and investigations. Assignments do not require the use of a balance of basic skills, conceptual understanding, and problem solving. Few assignments are open ended or allow multiple approaches; many are overly directed so that students do not have the opportunity to formulate mathematical questions, choose the approaches to take, reflect on the work they are doing, and make connections among the mathematical ideas. Few tasks require time and deliberations, and most are confined to a single day. Resources do not help teachers set a clear standard of performance for student work or suggest ways to help students meet the standard.
Students are asked to work individually and interact with one another. They often work in small heterogeneous groups to communicate their findings, orally or in writing. When working together, they are expected to share approaches, conjectures, difficulties, results, and evidence within their group and with other groups. Students are often asked to explore situations, gather data, and present their conclusions to other audiences, including interacting with members of their families in homework assignments.	More than half the time, students are asked to interact with one another. They often work in small heterogeneous groups to communicate their findings, orally or in writing. When working together, they are expected to share approaches, conjectures, difficulties, results, and evidence within their group and with other groups. At times, they are asked to explore situations, gather data, and present their conclusions to other audiences, including interacting with members of their families in homework assignments.	Students are infrequently asked to interact with one another, and when they are, their communication is limited to their results and does not usually include their approaches, conjectures, difficulties, and evidence. They are rarely expected to communicate their thinking in writing, or to communicate to other groups or other audiences, such as members of their families, in homework assignments.
Students are directed to use manipulative resources and technology to explore ideas and solve problems. It is assumed that a variety of tools is continually available for students to use and that every student has access to a calculator at all times and may choose to use it for any occasion except when the purpose is developing mental dexterity.	Students are often directed to use manipulative resources and technology to explore ideas and solve problems. Students have the choice of tools to use, although some of the choices may be limited or are made for the students.	Students are rarely directed to use manipulative resources and technology to explore ideas and solve problems, and when they do, they have a limited choice of tools to use or ways to use them.

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Evaluation Table: Student Diversity

Student Diversity (5)	Student Diversity (3.5)	Student Diversity (1)
All students participate fully in each unit; assistance provided to students having difficulty is in addition to, not instead of, the regular program, with the goal of supporting successful participation in the regular program. The tasks and problems students work on are accessible to all students. Many problems are rich and open and can be investigated at many different levels. Many tasks or lessons use students' personal, family, or cultural experiences to create the specific context for the lesson and to include parents as partners in the process. There is room in each unit for some students to pursue depth, complexity, or novelty in some aspect of the unit's investigations, according to their interests or their rapid grasp of the ideas.	All students participate in each unit. The entry point for tasks and problems is accessible to all students, but there is a gradient of difficulty that may sort students by their speed or verbal fluency. At that point, temporary assistance is provided to students having difficulty in lieu of keeping them in the regular program. Remaining students are provided with rich and open activities, in contrast to the narrow and mechanical activities that may be provided for the students having difficulty. Some tasks or lessons use students' personal, family, or cultural experiences to create the specific context for the lesson, and most often include parents as partners in the process. There is room in many units for some students to pursue depth, complexity, or novelty in some aspect of the unit's investigation according to their interests or their rapid grasp of the ideas.	All students participate in each unit. The entry point for tasks and problems is not always accessible to all students, and there is a steep gradient of difficulty that quickly sorts students by their speed or verbal fluency. Assistance for students having difficulty keeps them out of the regular program and limits their experience to narrow and mechanical tasks. Few tasks or lessons use students' personal, family, or cultural experiences to create the specific context for the lesson. Parents are not often included as partners in the progress. There is little room in most units for some students to pursue depth, complexity, or novelty in some aspect of the unit's investigations, according to their interests or their rapid grasp of the ideas.
The regular program is specifically made accessible to English language learners (ELL) by providing editions in the five most common languages other than English spoken in California, comparable in quality to those written in English, or by providing glossaries; summaries of key concepts; and directions, instructions, and/or problems and tasks in these five primary languages.	The regular program is made somewhat accessible to English language learners (ELL) by providing editions in Spanish as well as in at least two languages other than English, comparable in quality to those written in English, or by providing glossaries; summaries of key concepts; and directions, instructions, and/or problems and tasks in these four primary languages.	The regular program is not generally accessible to English language learners (ELL). Directions, instructions, problems and tasks, and/or glossaries and summaries are not provided in any language other than English.
The resources provide teachers with general advice on all of the following points and frequent lesson-specific suggestions to support the learning of all students, including: • ways to encourage students to connect lessons and content of lessons to their personal, family, or cultural experience; • ways to encourage students to value the points of view and the experiences of others; • the use of peer support and collaborative learning groups; and • how to work with students whose primary language is not English, including techniques for the use of the primary language and Specially Designed Academic Instruction in English (SDAIE) so that the program for these students is not limited or diluted. The focus in this criterion is to allow ELL (LEP) students accessibility to the program.	The resources provide teachers with general advice on all of the following points. and occasional lesson-specific suggestions, as applicable, to support the learning of all students, including: • ways to encourage students to connect lessons and content of lessons to their personal, family, or cultural experience; • ways to encourage students to value the points of view and the experiences of others; the use of peer support and collaborative learning groups; • and how to work with students whose primary language is not English, including techniques for the use of the primary language and Specially Designed Academic Instruction in English (SDAIE) so that the program for these students is not limited or diluted. The focus in this criterion is to allow ELL (LEP) students accessibility to the program.	The resources provide teachers with general advice on all of the following points and a few lesson-specific suggestions to support the learning of all students, including: • ways to encourage students to connect lessons and content of lessons to their personal, family, or cultural experience; • ways to encourage students to value the points of view and the experiences of others; • the use of peer support and collaborative learning groups; and • how to work with students whose primary language is not English, including techniques for the use of the primary language and Specially Designed Academic Instruction in English (SDAIE) so that that the program for these students is not limited or diluted. The focus in this criterion is to allow ELL (LEP) students accessibility to the program.

Evaluation Table: Assessment

Assessment (5)	Assessment (3.5)	Assessment (1)
Assessment is consistently integrated into the instructional program. The instructional resources help teachers use assessment in a variety of ways to get information about what the student or groups of students understand and are able to do in solving mathematical problems. Assessment measures a balance of basic skills, conceptual understanding, and problem solving within the eight strands of mathematics.	Assessment is generally integrated with the instructional program. The instructional resources help teachers use assessment in a variety of ways to get information about what the student or groups of students understand and are able to do in solving mathematical problems. Assessment frequently measures a balance of basic skills, conceptual understanding, and problem solving within the eight strands of mathematics.	Assessment is not integrated with the instructional program. The instructional resources do, however, help teachers use assessment to get information about what the student or groups of students understand and are able to do in solving mathematical problems. Assessment does not measure a balance of basic skills, conceptual understanding, and problem solving within the eight strands of mathematics.
Specific assessment tasks are included in the units, though they may or may not be distinguished from learning tasks because they have similar characteristics. Specifically, students formulate problems, consider and apply a variety of approaches, determine and explain their findings; use tools, such as calculators and manipulatives, and other resources, such as notes or reference materials; and have ample time to work on assessment tasks to revise and resubmit important assignments to bring performance up to high-quality standards.	Specific assessment tasks are included in the units and display most of the following desirable characteristics: students formulate problems, consider and apply a variety of approaches, determine and explain their findings; use tools, such as calculators and manipulatives, and other resources, such as notes or reference materials; and have ample time to work on assessment tasks and frequently have the opportunity to revise and resubmit important assignments to bring performance up to high-quality standards.	Specific assessment tasks are included in the units. They display only a few of the following desirable characteristics: students formulate problems, consider and apply a variety of approaches, determine and explain their findings; use tools, such as calculators and manipulatives, and other resources, such as notes or reference materials; and have ample time to work on assessment tasks and frequently have the opportunity to revise and resubmit important assignments to bring performance up to high-quality standards.
The resources include general suggestions to the teacher concerning the following, with frequent unit-specific suggestions: • how to use learning tasks for assessment purposes; • how to observe, listen to, and question students while they work, as well as how teachers might keep track of insights they may have about the students; • how to organize and use student portfolios; • how teachers can keep parents informed about the progress of their children and about the variety of assessment methods being used: both what they are and why they are important; and • how to involve students in self-assessment.	The resources include general suggestions to the teacher concerning the following, with occasional unit-specific suggestions: • how to use learning tasks for assessment purposes; • how to observe, listen to, and question students while they work, as well as how teachers might keep track of insights they may have about the students; • how to organize and use student portfolios; • how teachers can keep parents informed about the progress of their children and about the variety of assessment methods being used: both what they are and why they are important; and • how to involve students in self- assessment.	The resources include general suggestions to the teacher concerning the following, with few unit-specific suggestions: • how to use learning tasks for assessment purposes; • how to observe, listen to, and question students while they work, as well as how teachers might keep track of insights they may have about the students; • how to organize and use student portfolios; • how teachers can keep parents informed about the progress of their children and about the variety of assessment methods being used: both what they are and why they are important; and • how to involve students in self-assessment.

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Evaluation Table: Support for the Teacher

Support for the Teacher (5)	Support for the Teacher (3.5)	Support for the Teacher (1)
The resources provide many lesson- and unit-specific suggestions and illustrative examples of how the teacher can instruct and facilitate the student behaviors identified under "The Work Students Do." The resources include the following: • description of the important mathematical ideas in the units, including how students are to encounter the mathematical ideas and how the experiences are related to what is known about children's learning or developmental level; • description/pictures of what units and lessons will look like when implemented in the classroom; • information about what is important to do and say in a lesson or unit; • suggestions for questions to ask and ways to respond that keep students' thinking open and help them on what they have done, how teachers might think about and reflect on what happens in a lesson or unit, when it makes sense to present information to students and how to do it; • suggestions for working with a diverse classroom of students, helping students work together productively, as well as managing manipulative materials, calculators, computers, and other tools so they are accessible when students want to use them; • suggestions for helping students communicate more effectively about their mathematical thinking; • suggestions for involving parents and keeping them informed about the program; and • suggestions for assessing student performance.	The resources provide information, suggestions, and some illustrative examples of how the teacher can instruct and facilitate the student behaviors identified under "The Work Students Do." The materials include most of the following: • description of the important mathematical ideas in the units, including how students are to encounter the mathematical ideas and how the experiences are related to what is known about children's learning or developmental level; • description/pictures of what units and lessons will look like when implemented in the classroom; • information about what is important to do and say in a lesson or unit; • suggestions for questions to ask and ways to respond that keep students' thinking open and help them reflect on what they have done, how teachers might think about and reflect on what happens in a lesson or unit, when it makes sense to present information to students and how to do it; • suggestions for working with a diverse classroom of students, helping students work together productively, as well as managing manipulative materials, calculators, computers, and other tools so they are accessible when the students want to use them; • suggestions for helping students communicate more effectively about their mathematical thinking; • suggestions for involving parents and keeping them informed about the program; and • suggestions for assessing student performance.	The resources provide limited information, suggestions, and few illustrative examples of how the teacher can instruct and facilitate the student behaviors identified under "The Work Students Do." Many of the suggestions are general rather than lesson or unit specific in nature. The materials include few of the following: • description of the important mathematical ideas in the units, including how students are to encounter the mathematical ideas and how the experiences are related to what is known about children's learning or developmental level; • description/pictures of what units and lessons will look like when implemented in the classroom; • information about what is important to do and say in a lesson or unit; • suggestions for questions to ask and ways to respond that keep students' thinking open and help them reflect on what they have done, how teachers might think about and reflect on what happens in a lesson or unit, when it makes sense to present information to students and how to do it; • suggestions for working with a diverse classroom of students, helping students work together productively, as well as managing manipulative materials, calculators, computers, and other tools so they are accessible when the students want to use them; • suggestions for helping students communicate more effectively about their mathematical thinking; • suggestions for involving parents and keeping them informed about the program; and • suggestions for assessing student performance.

K-8 Mathematics Instructional Resources Evaluation Form

Publisher ____________________

Title ____________________

Grade Span ____________________

Category	Rating	Weight		Total
Mathematical Content	_____	x 4	=	_____
Program Organization and Structure	_____	x 3	=	_____
The Work Students Do	_____	x 5	=	_____
Student Diversity	_____	x 2	=	_____
Assessment	_____	x 2	=	_____
Support for the Teacher	_____	x 4	=	_____
		Overall Weighted Total		_____

Council of Chief State School Officers (CCSSO) State Curriculum Frameworks and Standards Map: Definitions of Categories and Concepts

1. Subject(s) of Framework

A. Title: *Official and complete title of framework or standards document(s)*

B. Date of document reviewed:

C. Status of framework: *Classify the current status in terms of one of the following three phases:* (Select one)

- **Developing or working draft:** Document is in a predistribution and development phase; it is not yet disseminated for formal review beyond a limited circle of writers or experts.
- **Review draft:** Document is a completed draft that is being formally disseminated for comment and final revisions.
- **Adopted:** Document serves as official guidance, mandate, or policy.

D. Implemented/Disseminated:

E. Planned revision date:

F. Main components of document:
(Components present—example list)

- **Content standards:** Content knowledge and skills students are expected to know and be able to do in mathematics or science, often by grade level.
- **Performance standards (or outcomes):** Description of the levels of proficiency to which content standards shall be attained by students.
- **Pedagogy/Instructional strategies:** Pedagogical approaches, ideas, procedures, and processes of teaching recommended for use with curriculum.

- **Linking to policies and enabling conditions:** Policies or guidelines for assessments, professional development, curriculum design and organization, materials and texts, school and system support, technology, and facilities.
- **Implementation plan for state:**
- **Assessment plans, examples:**

G. Single vs. multiple subjects: *Framework document includes one subject or multiple subjects.*

H. Related documents:

- Key state-designed and disseminated documents, in addition to the framework, related to the curriculum framework or standards (referenced or identified from other information). Indicate author(s), title, and publication date.

2. State Context

A. State's vision for mathematics and science:

- Specific to one subject vs. broad, general.
- Contains specific information about needs, interests of state vs. general statement of vision.
- Page number for vision statement.

B. Intent or purpose of the framework/standards: *Indicate which of the following concepts best describe the rationale, goals, or purpose, as stated in the framework; add any concepts the state identifies that are not described by these overarching statements.*

- Develop student knowledge and habits of mind.
- Modernize and change instruction.
- Design recommended curricula and instructional resources.
- Ensure equity and access for all students.
- Make or implement assessment/evaluation policy.
- Involve parents, business, and other community members.
- Other.

C. Major sources: *Major national documents or reports, especially: National Council of Teachers of Mathematics'* Curriculum and Evaluation Standards for School Mathematics, Teaching Standards, Assessment Standards*; National Academy of Sciences/National Research Council National Science Education Standards; American Association for the Advancement of Science* Benchmarks*; other states' frameworks or reports; or other studies or reports referenced in the opening sections of the framework that establish the vision and define the conceptual foundation for science/mathematics education.*

- Reference page numbers for national documents.
- Characterize how they are used or modeled closely after national documents; frequent references; listed as resource.
- List other states that are referenced as sources.

D. Mandates or state initiatives supporting frameworks and standards: *Major funding initiatives (internal or external, regulatory or advisory), supplemental financial resources, legislative or board-sponsored mandates, requirements, and supportive arrangements that advanced or contributed to the development and/or implementation of the framework. Mention here any specific decisions that enhance local resources; technology; use of school time; professional development; facilities; schedules, and so forth.*

- Legislative or state board mandates, rules, or regulations.
- External funding—from federal, non-profit agencies, and so forth. (List the funding sources/agencies).

E. Target audiences: *The key groups that the framework was designed to inform, assist, or advise, particularly those expected to make most immediate and regular use of the framework to carry out their mission and primary responsibilities.*

- **Teachers:** Teachers in all subjects and for all grades or special groups; and certified support personnel such as media specialists, counselors, and so forth.
- **School and district curriculum planners:** Curriculum and instructional supervisors, designers, or writers.

- **School administrators:** Administrators at school site and central office levels.
- **Assessment developers:** Test or item authors, contractors designing test and item specifications, administrators or assessment managers.
- **Board members:** Members of district school boards and/or school-site boards or management teams.
- **Parents:** PTA organizations, individual parents, and other parent advisory or participant groups.
- **Business partners:** Business or industry partners who work in a formal relationship with schools or school boards.
- **Other community constituents:** Public sector agencies and other parent or public groups working with the school system.
- **Other:** Indicate other users/audiences not indicated above.

F. <u>Key development activities</u>: *Major steps that best describe phases, events, or processes that were used in completing the current edition of the framework if the development process is described in the document.*

- Expert panel(s) and/or advisory committee(s).
- Reviews and analyses of other similar or model documents.
- Suggestions, ideas, and exemplars from teachers, educators, and subject specialists.
- Teacher participation in writing and editing for the framework's text (including writing of suggested standards).
- Successive drafts were written, reviewed, and modified.
- Focus groups for review/discussion of drafts.
- Pilot study in districts and/or classrooms.
- Wide dissemination within schools and throughout communities and the state.
- Other (indicate other activities that differ from those listed above).

3. Standards

A. Content standards: *Categories or headings that organize subject content and indicate the term(s) used for the categories, for example, strands, standards, themes, disciplines, and so forth. List only the broad outline; include examples of detail in the sample* Standards *in the next section. Describe the state's definition and uses of content or performance standards as specified in the framework document.*

- **Definition:** Quote or paraphrase, page reference.
- **Number of standards:**
- **Grade levels/clusters of standards:** If content categories differ greatly across grade levels, separately list content clusters for each grade level or group.

Supply example of *content standard* for subject area.

B. Benchmarks/Indicators: *Next level of detail below* Standards.

- **Definition:** *Term used for this level.*
- Number of benchmarks per *Standard.*
- Grade levels/clusters of this level.

Supply example of a benchmark that matches the *content standard* included above.

C. Cross-cutting themes: *Concepts for organizing and implementing curriculum content that transcend framework's major content organizers, including processes, themes, attitudes, habits of mind, and so forth. They appear repeatedly across several components or sections of the framework, in various content areas and topics.*

4. Performance Standards

A. State's definition and term for performance standards: *Where they are found and name of document. How they are related to content standards.*

- Short quote on definition, page number.
- Number of performance standards; grade clusters.

Supply example of performance standard that matches *content standard* defined above.

B. <u>Performance standards are designed and described to be used for developing</u>:

- External accountability/state assessment.
- End-of-course assessment.
- Student accountability/classroom assessment.

Describe use(s) for state from interviews.

5. Assessment

How assessment is related to standards:

- Classroom or instructional assessment.
- Accountability.
- Examples of assessments and page numbers.
- Types of exercises/tasks described or modeled.

6. Features

Methods of presenting and communicating content used ***regularly and throughout*** *the document to illustrate the recommended curriculum content or pedagogical practices. (Indicate page numbers for good examples.)*

- **Vignettes:** *Illustrative classroom scenarios or essays that describe teaching, situating instruction in a context that demonstrates the give and take among children and their teachers and shows with considerable descriptive detail how teachers define in practice specific content areas and instructional approaches. Vignettes often include dialogue.*
- **Models or examples of instructional practice:** *"How to" examples of techniques or thumbnail sketches of practice. Compared with vignettes, models are shorter and more static, and they do not attempt to reflect classroom context, discourse, or exchanges that occur among teachers and students.*
- **Activities and/or instructional tasks:** *Lists or outlines of activities or tasks, reported with a minimum of detail, surrounding context, give or take, or dialogue.*
- **Diagrams, graphics, photographs:** *Visuals used to model or illustrate the instructional activities, tools, structures, patterns, or approaches.*
- **Other unique features:** *(ways of presenting content, etc.)*

7. Linkages to Policies and Enabling Conditions

Linkages of content to policies and recommended enabling conditions: *Extent of alignment of framework's vision, content, standards, and pedagogy with other state education policies, or with policy decisions that are left to district or school levels; policies that enable teachers and schools to improve mathematics/science. Record the linkages within one of the following two dimensions:*

- Current and existing policy links are reported within the document.
- Policy linkages are proposed and/or recommended, but they are not yet regulated by statute or rule.

Framework/Standards Linkages (Content links to following)	Existing links reported in document	Links are recommended
Professional development		
Assessment for external accountability		
Selecting, developing, or using materials and textbooks		
Teacher preparation and certification		
Student support services		
School and curriculum organization, decision making, uses of time, district and school support		
Technology integration		
Involving community representatives, parents, and business leaders in planning, review, and policy-making committees		
Facilities		

- Other documents providing linkages to content standards.

8. Equity

Indicate the ways the framework document addresses race/ethnicity, gender equity, inclusiveness, and attentiveness to handicapping conditions in the curriculum. Framework clearly describes or illustrates state recommendations for any one equity element that is checked.

- Where/in which sections is equity treated?
- How is it treated? Cite examples and page numbers.
- List examples of where equity is treated.
- **Rationale and vision statements:** *(e.g., importance of all students learning mathematics/science in K-12, how framework will aid this goal.)*
- **Vignettes, activities, and sample problems:** *(Examples are multiracial/ethnic and cross-gender; refer to education for culturally diverse, handicapped, and limited-English-speaking students; and describe diverse teaching and learning situations.)*
- **Instructional strategies, curriculum organization:** *(e.g., including content and instructional techniques that nurture the needs of students from varied backgrounds, experiences, cultures, and communities.)*
- **Curriculum organization and course structure***: (e.g., detracking curriculum; integrated courses and teacher assignments involving multicultural communities in teaching and learning.)*
- **Materials selection and distribution:** *(e.g., guidelines for materials selection reflect high standards for all groups.)*
- **Assessment approaches:** *(e.g., strategies that are sensitive to racial/ethnic and gender differences, minimize bias, and maximize opportunities for students to demonstrate their knowledge in various ways.)*
- **Staff development:** *(e.g., proposes strategies to reach educators with few development opportunities.)*
- **Teacher preparation:** *(e.g., designs that prepare teachers to teach mathematics/science content to diverse student groups.)*
- **Hiring practices:** *(examples of incentives for increasing numbers of minority teachers and administrators.)*
- **Community and business involvement:** *(e.g., suggested mechanisms for increasing the involvement of diverse groups.)*
- **Policies and recommendations:** *(e.g., state policies that promote equity and inclusiveness in teaching, curriculum, assessment, and hiring.)*

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9. Pedagogy

The approach to teaching and learning—the instructional strategies, processes, or activities recommended, proposed, or modeled—and the means by which these ideas are presented. Pedagogy categories are based on the NCTM Curriculum and Evaluation Standards for School Mathematics *(1989) and on the AAAS* Science for All Americans *(1989).*

A. Explanation of Columns:

- **Lists**: *Items are listed or outlined with little or no detail about how pedagogical elements are to be used within classrooms or by teachers.*
- **Vignettes and examples**: *Illustrative stories with specific examples, "how to" statements describing a story line, or portraits exploring the discourse and instructional processes among students and their teachers. These may include dialogue, thinking, and reflective practice by both teachers and students.*
- **Context**: *In many places throughout the framework, pedagogy is demonstrated through lists, diagrams, pictures, and/or portraiture that tell the tale of events and processes in action.*

Pedagogical Practices	Lists	Vignettes and Examples	Context
Constructive and active lessons			
Technological applications			
Multiple assessment strategies			
Discourse, dialogue, and argument			
Flexible uses of time and facilities			
Working with a mix of tools, manipulatives, textbooks, and resources			
Experiments and multiple solutions			
Representation, including writing, mapping, diagramming, graphing, and so forth			

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B. Definitions for pedagogical practices: *The framework suggests, models, or describes the following pedagogical practices:*

- **Constructive and active lessons:** *Students actively engage with content, materials, tools, and/or peers to build understanding of mathematical and scientific ideas, solutions, or explanations.*
- **Technological applications:** *Students use various technological tools (calculators, including those that graph, and computers) to derive mathematical and scientific solutions.*
- **Multiple assessment strategies:** *Teacher observations, conferences, self-assessments, student journals; projects, experiments, constructions; writing, tasks, and real-world problems to solve; formal and informal tests; oral presentations; and so forth.*
- **Discourse, dialogue, and argument:** *Verbal representations of the logic underlying mathematical and scientific ideas; strategies call upon students to discuss, prove their point of view, probe one another's as well as the teacher's thoughts; and so forth.*
- **Flexible uses of time and facilities:** *Varying time blocks, classroom spaces, libraries, laboratories, and so forth are suggested as resources for learning mathematics and science.*
- **Working with a mix of tools, manipulatives, textbooks, and resources:** *Activities and tasks suggest ways to involve students in a wide range of mathematical and scientific problem-solving tools and materials.*
- **Experiments and multiple solutions:** *Tasks demonstrate ways that mathematics and science are incorporated into applied contexts through problem solving, experiments, and experiences that lend themselves to alternative solutions with no single "best" answer or solution strategy.*
- **Representation, including writing, mapping, diagramming, graphing, and so forth:** *Students are encouraged to explain mathematics and science in various formats, including pictures, diagrams, spreadsheets, models, maps, and so forth, as well as verbally.*

10. Other Framework Components

Major sections or chapters of state framework not addressed by preceding categories.

EXECUTIVE SUMMARY OF *A SPLINTERED VISION: AN INVESTIGATION OF U.S. SCIENCE AND MATHEMATICS EDUCATION*

THE SPLINTERED VISION: AN OVERVIEW

There is no one at the helm of mathematics and science education in the United States; in truth, there is no identifiable helm. No single coherent vision of how to educate today's children dominates U.S. educational practice in either subject, nor is there a single, commonly accepted place to turn to for such visions. Our visions—to the extent that they exist at all—are multiple.

These splintered visions produce unfocused curricula and textbooks that fail to define clearly what is intended to be taught. They influence teachers to implement diffuse learning goals in their classrooms. They emphasize familiarity with many topics rather than concentrated attention to a few. And they likely lower the academic performance of students who spend years in such a learning environment. Our curricula, textbooks, and teaching all are "a mile wide and an inch deep."

This preoccupation with breadth rather than depth, with quantity rather than quality, probably affects how well U.S. students perform in relation to their counterparts in other countries. It thus determines who are our international "peers" and raises the question of whether these are the peers that we want to have. In today's technologically oriented global society, where knowledge of mathematics and science is important for workers, citizens, and individuals alike, an important question is: What can be done to bring about a more coherent vision and thereby improve mathematics and science education?

Reforms have already been proposed by political, business, educational and other leaders. Extensive efforts are underway to implement these standards, but the implementation process itself is shaped by the prevailing culture of inclusion. Like the developers of curricula and the publishers of textbooks, teachers add reform ideas to their pedagogical quivers without asking what should be taken away.

The study summarized below represents an effort to describe the nature of the diffuse vision of mathematics and science education in the United States and to raise questions relevant to policy making.

PURPOSE OF *A SPLINTERED VISION*

A Splintered Vision (written by William Schmidt, Curtis McKnight, and Senta Raizen of the U.S. National Research Center for the Third International Mathematics and Science Study and published by Kluwer Academic Publishers) discusses data from the analysis of 491 curriculum guides and 628 textbooks from around the world as part of the recently completed Third International Mathematics and Science Study (TIMSS). It also presents detailed accompanying data on teacher practices in the United States and two other countries: Germany and Japan.

The TIMSS is a large-scale, cross-national comparative study of the national educational systems and their outputs in about 50 countries. Researchers examined mathematics and the sciences curricula, instructional practices, and school and social factors, as well as conducting achievement testing of students. They collected data from representative documents that laid out official curricular intentions and plans, analyzed entire mathematics and science textbooks, and searched entire K-12 textbook series for selected "in-depth" topics (subareas within the subject matter.) In six countries TIMSS conducted classroom observations, teacher interviewing, and videotaping.

The TIMSS curriculum and teacher data are extensive and cannot be explored in a single report. The results of analyses of these data are being reported in a series of volumes, three of which are now available.[1]

The present report intends to document and characterize the state of U.S. mathematics and science curricula, textbooks, and teaching practices and place them in a cross-national context. Unfortunately, this study could provide only a snapshot of the "moving target" that is educational practice in the United States These data were collected in 1992-93, when the mathematics standards had existed for only three years and the science standards were not finalized.[2] The intervening years have been a time of change for state curriculum standards and textbooks. The TIMSS data on teacher practices discussed here were collected in 1995.

This report is meant to be descriptive and, to a lesser extent, interpretive. It is not a plea for specific reforms. We seek to provide data germane to the ongoing public debate about science and mathematics education policies in the United States.

UNFOCUSED CURRICULA

Curricula in both mathematics and science in U.S. schools are unfocused in comparison with those in other countries studied. The lack of curricular focus is more true in mathematics than in science, though physical science guides closely resemble mathematics in their fragmentation. U.S. curricula are unfocused in several respects:

Topics Covered

Mathematics curricula in the United States consistently cover far more topics than is typical in other countries. The number of mathematics topics in the U.S. composite[3] is higher than the 75th percentile internationally in all grades until ninth, when schools typically teach specific courses such as algebra, geometry, etc.

In science, the tendency toward inclusion is similar, though less pronounced. The number of science topics in the U.S. composite exceeds the 50th percentile internationally in all but one grade until the tenth, when schools tend to abandon general science approaches for specific courses, such as chemistry and physics.

Repetition

In both mathematics and science, topics remained in our composite U.S. curricula for more grades than all but a few other TIMSS countries. The U.S. approach can be characterized as "come early and stay late."

In mathematics, the U.S. practice is to add far more topics than other countries do in grades one and two and then repeat these topics until grade seven. In grades nine and 11 the U.S. composite curriculum drops many more topics than other countries. On average, mathematical topics remain in the U. S. composite curriculum for two years longer than the international median. Only five countries have higher average durations.

In science, U.S. practice is to introduce new science topics at intervals, especially grades one and five, with little change in the intervening grades. In grades 10 to 12, the U.S. composite curriculum drops many more topics than other countries. Average intended duration is close to the international median in earth sciences and life sciences, but the U.S. average duration in the physical sciences is two years longer than the median and higher than all but seven countries.

In mathematics, the tendency to retain topics over many grades may reflect the traditional approach of distributed mastery—the idea that mastering pieces of a subject would lead to mastery of a bigger whole. U.S. curricula lack a strategic concept of focusing on a few key goals, linking content together, and setting higher demands on students.

This propensity for inclusion extends even to reform proposals. Many reform recommendations simply add to the existing topics (or are implemented by adding to existing content), thereby exacerbating the existing lack of curricular focus.

Emphasis

U.S. curricula in mathematics and science seek to do something of everything and less of any one thing. Given roughly comparable amounts of instructional time, this topic diversity limits the average amount of time allocated to any one topic.

In mathematics, this accumulation may be a product of our model of distributed mastery over the grades.

The reasons for the better results in science are less clear but seem related to general science approaches that move from topic to topic.

Variations Among States

While the core of mathematics topics was broad, it varied little among the states.

The number of core science topics was much smaller, and the overlap among state curricula was also small. While students in U.S. states might have studied a number of science topics roughly equal to the international median, the differing curricular intentions of various states are such that students in different states likely studied only a few common topics.

Defining the "Basics"

Student achievement in mathematics and science in any country is largely shaped by what educational policymakers in that nation regard as "basic" in these subjects and how well they communicate and support those basics.

The U.S. mathematics instructional practices defined *de facto* eighth-grade basics of arithmetic, fractions, and a relatively small amount of algebra. In Germany, Japan, and internationally, the basics were defined as algebra and geometry.

For science, the picture is more complex since U.S. curricula include single-area courses, such as physical sciences, life sciences, or earth sciences. These courses defined a more restricted, focused set of basics, but they applied only to the subset of students receiving those particular courses.

Unfocused Textbooks

Textbooks play an important role in making the leap from intentions and plans to classroom activities. They make content available, organize it, and set out learning tasks in a form designed to be appealing to students. Without restricting what teachers *may* choose to do, textbooks drastically affect what U.S. teachers are *likely* to do under the pressure of daily instruction. The question thus arises: Do U.S. mathematics and science textbooks add guidance and focus to help teachers cope with unfocused curricula?

Unfortunately, the answer is "no." The splintered character of mathematics and science curricula in the United States is mirrored in the textbooks used by teachers and students. Textbooks are unfocused in several ways:

Topics Included

The U.S. mathematics and science textbooks include far more topics than was typical internationally at all three grade levels analyzed.

In mathematics, U.S. textbooks are far above the 75th percentile of the TIMSS countries in the number of topics covered. For example, U.S. mathematics textbooks designed for fourth and eighth graders cover an average of 30 to 35 topics, while those in Germany and Japan average 20 and 10 respectively for these populations.

As a result, typical mathematics textbooks in the United States look quite different than those of a nation such as Japan. The typical eighth-grade U.S. textbook (non-algebra) is larger and more comprehensive than the average Japanese text, but it contains fewer sequences of extended attention to a particularly important topic. The U.S. textbooks' sequences are also shorter and have more breaks. The lesson-by-lesson organization of the U.S. book is much less focused than the Japanese book, and there is far more skipping among topics in successive segments.

In science, the differences are even greater. At all three population levels, U.S. science textbooks included far more topics than even the 75th percentile internationally. The average U.S. science textbook at the fourth, eighth, and 12th grade has between 50 and 65 topics; by contrast Japan has five to 15 and Germany has just seven topics in its eighth-grade science textbooks.

Emphasis

The propensity of U.S. curricula to do something of everything but little of any one thing is mirrored in textbooks. The few most emphasized topics account for less content than is the case internationally.

Among the fourth-grade mathematics textbooks investigated, the five topics receiving the most textbook space accounted on average for about 60 percent of space in the U.S. textbooks but over 85 percent of textbook space internationally.

At the eighth-grade level, the five most emphasized topics in non-algebra U.S. textbooks accounted for less than 50 percent of textbook space compared to an international average of about 75 percent. An exception is U.S. eighth-grade algebra books, which were highly focused, with the five most emphasized topics accounting for 100 percent of the books.

Among the U.S. fourth-grade science textbooks investigated, the five topics receiving the most attention accounted for an average of just over 25 percent of total space in U.S. textbooks compared to an average of 70 to 75 percent internationally.

Among the U.S. eighth-grade science textbooks investigated, the five most emphasized topics in more general science texts accounted for about 50 percent of textbook space compared to an international average of about 60 percent. In contrast, U.S. eighth-grade science books oriented to a single area were highly focused, with the five most emphasized topics accounting for more of the textbooks than was true in the international average.

Difficulty

U.S. eighth-grade science textbooks emphasized understanding and using routine procedures, which represent the less complex, more easily taught expectations for student performance. This emphasis was typical of what was done internationally. It is not, however, typical of the diverse and more demanding performances called for in current U.S. science education reform documents.

Most U.S. schools and teachers make selective use of textbook contents and rarely, if ever, cover all of a textbook's content. Publishers can reasonably expect that those who adopt and buy a particular textbook will feel free to use only the contents that suit their purposes. Unfortunately, the result is large textbooks covering many topics but comparatively shallowly. Even in the largest textbooks, space is still limited. It is impossible for textbooks so inclusive to help compensate for unfocused official curricula. Thus, our analysis shows that U.S. textbooks support and extend the lack of focus seen in those official curricula.

How Teachers Deal with the Splintered Vision

Teachers in the United States are sent into their classrooms with a mandate to implement inclusive, fragmented curricula and armed with textbooks that embody the same "breadth rather than depth" approach. How do they handle such a situation? Not surprisingly, the instructional decisions made by U.S. teachers mirror the inclusive approach of the tools they are given. U.S. teachers handle the splintered vision they get in several ways:

Topics Covered

U.S. mathematics and science teachers typically report teaching more topics than their counterparts in other countries, including Germany and Japan. This is true for science teachers even when using a single-area textbook such as physical science, life science, or earth science.

Emphasis

Since instructional time for science or math within a school year is limited, the data show that teaching more topics means that teachers spend little time on most topics.

U.S. eighth-grade mathematics teachers indicated that they taught at least a few class periods on all but one topic area included in the teacher survey's questionnaire. They devoted 20 or more periods of in-depth instruction to only one topic area, fractions and decimals. However, in Germany and Japan many other topic areas received this more extensive coverage.

According to the survey, the five topic areas covered most extensively by U.S. eighth grade mathematics teachers accounted for less than half of their year's instructional periods. In contrast, the five most extensively covered Japanese eighth-grade topic areas accounted for almost 75 percent of the year's instructional periods.

U.S. eighth-grade science teachers also indicated that they would devote at least some class time to every topic area surveyed. None was omitted completely and no topic was marked to receive more than 13 class periods of attention by eighth-grade physical and general science teachers. Additional topic areas received more extensive coverage in Germany and Japan.

On average, U.S. eighth-grade general science teachers' most extensively covered topics accounted for only about 40 percent of their instructional periods, but this percentage was also lower for science in Germany and Japan (about 50 to 60 percent).

Number of Activities

U.S. teachers engage in more teaching activities per lesson than their counterparts in other countries. More than 60 percent of U.S. eighth-grade mathematics and science teachers reported using six or more activities in a typical class. In Germany only 25 percent reported using six or more activities, and even fewer reported doing so in Japan.

Is This The Best Our Teachers Can Do?

U.S. mathematics and science teachers work hard and often face demanding workplaces. Our data show that they are scheduled to work about 30 periods each week, which is more than teachers in Germany (just over 20 periods) and Japan (fewer than 20).

These teachers rarely have the luxury of being idealists. Unfocused curricula and inclusive textbooks set few boundaries for instructional decisions and appear to require a little bit of everything. It is easier for real teachers making real decisions in the real workplaces of U.S. schools to settle for the first alternative that seems good enough rather than search for the best possible instruction. They try to *cover* as much as they can rather than *teach* just a little. In a word, they "satisfice."

The data show that U.S. mathematics and science teachers are aware of and believe in more effective, complex teaching styles than they practice. They often have information that would help them do their work more effectively. Their beliefs suggest that they might choose to organize instruction differently under circumstances less consumed by the need for coverage.

Effective teachers should not be unusual, nor should effectiveness require extraordinary efforts and dedication by teachers. The reality, however, is that U.S. teachers are placed in situations in which they cannot do their best. We have yet to unleash the effectiveness of U.S. teachers. It seems likely that fundamental changes are needed in teacher knowledge, working conditions, curricula quality, student expectations, and textbook content.

What Can We Expect from U.S. Students?

In mathematics, we have a highly fragmented curriculum, textbooks that are a "mile wide and an inch deep," and teachers who cover many topics but none extensively. We make low demands on students and have a more limited conception of "the basics" than the international norm. It seems highly likely that U.S. student achievement in mathematics will be below international averages.

Our science curriculum is less fragmented. Science achievement seems likely to be closer to international averages, but still not what we desire and certainly below some, if not most, of our economic peers.

U.S. students' achievements—the yield of our aggregate national education "system"—in mathematics and the sciences are likely to be disappointing and many of the reasons are not under students' control. We must make substantial changes if we are to compete and to produce a quantitatively and scientifically literate workforce and citizenry.

How Has Our Vision Become So Splintered?

Culture affects education, even in supposedly fixed disciplines such as mathematics and science. Countries differ in the priorities they give to these disciplines, in the way they organize instruction and the value they ascribe to academic success. The qualitative differences found in mathematics and science instruction across France, Japan, Spain, Switzerland, Norway, and the

United States suggest that strong cultural components, even national ideologies, are at work in the teaching of these subjects.

The current state of our nation's composite visions guiding mathematics and science education are clearly shaped by cultural forces particular to the United States, starting with the nation's decentralized approach to education.

A System With Many Actors

Education in the United States always has been guided by agencies and organizations — local, state, and national, official and unofficial—that take their share of responsibility for education. There are many actors, including states, schools, commercial publishers, national associations, test publishers, teachers, and the federal government. While the independence of these groups is essential to education in the United States, the result is a composite of sometimes corresponding, sometimes conflicting separate visions. The conversations that cumulatively shape the national visions of mathematics and science education in the United States appear to be held in the tower of Babel.

Our earlier statement that there was "no one helm" for mathematics and science education should not be taken as implying that there *should* be either a single helm or a single helmsman. At its best, our system of distributed educational responsibility allows local preferences and community needs to help determine what occurs in local schools. It also provides laboratories to test, implement, and replicate new approaches. At its worst, our system requires that we seek consensus on needed changes site by site.

Given the cultural context in which mathematics and science education is carried out in the United States, a decentralized system with many actors is inevitable. We hope the splintering is not.

A Diverse Market for Curricula and Textbooks

U.S. textbook publishers face varied, often conflicting, demands for what should be in mathematics and science textbooks. Official mathematics and science curricula vary widely among states and districts. Over 35 states have textbook adoption policies, but in many states districts are free to choose any textbook.

Textbook publishers are understandably eager to produce products that will appeal to as many markets as possible. The results are large textbooks that embrace virtually all suggestions offered by the various actors. They include something for everyone.

If a clear, coherent vision of what is important existed and was shared by virtually all textbook publishers, it is likely that the resulting materials could soon lead to wide official adoption reflecting that coherent vision.

Standardized Tests

The cacophony of conflicting demands seen in curricula and textbooks is exacerbated by pressures to provide for successful student performance on common standardized tests. These include state assessments and the National Assessment of Educational Progress (NAEP) tests, as well as commercially produced and locally mandated standardized tests.

Despite a seeming sameness about most standardized tests, there are differences in content emphases and student performance demands. These differences are sufficient to constitute yet another set of demands to try to reconcile.

Mass Production and Mass Education

U.S. education has been influenced profoundly by a deeply seated ideology springing from our national experience with the power of industrial and assembly-line production. This ideology revolves around the idea of producing uniform, interchangeable parts that can be assembled into desired wholes. Translated into education, such thinking views school mathematics and science as partitioned into many topics that form the building blocks of curricula. As a result, our students may grasp the pieces but not the whole.

We have applied the term *incremental assembly* to this ideology and believe that it may well keep the United States from finding other, more coherent and powerful ways to think about and organize curricula. This is unfortunate. Henry Ford, presumably, did not try to make all models simultaneously on the same assembly line.

The lack of focus in U.S. mathematics and science education also has roots in behavioral psychology, which has pushed education in the direction of behavioral objectives and programmed instruction. This notion may help explain our curricula of many small topics, frequent low demands, and interchangeable pieces of learning to be assembled later.

The Impact of Reform

In the U.S. today we live in a climate of reform and talk of reform. Professional organizations concerned with mathematics and science education issue platform documents setting out agendas, benchmarks, and "standards." These powerful, demanding, and insightful calls for reform offer coherent visions of what might be done to make major improvements in their targeted educational practices. What has been their impact on mathematics and science education?

Awareness of Reforms

As late as two years ago, state mathematics and science curriculum guides, plans, and statements of intentions still called for coverage of far more topics than most other countries did and, far more than would be indicated by current reform agendas in mathematics and science education. The same can be said of textbooks.

U.S. mathematics and science teachers are generally aware of these reforms. More than 75 percent of U.S. mathematics teachers indicated familiarity with the NCTM *Standards*. Fewer U.S. science teachers indicated similar familiarity with the corresponding science frameworks, but those were released five years after the mathematics report.

These data suggest that more time alone will not be enough. Failure to create widespread change in teaching practice does not appear to be due to lack of information.

An Unfocused Reform

U.S. mathematics and science educators approach reform in the same inclusive style as they deal with traditional content—they add its recommendations but do not take away. This is clearly contrary to the recommendations of the NCTM *Standards*. Textbooks have been affected to some extent by mathematics education reform recommendations, but in a similar inclusive manner. As a result, students cannot focus on or be successful in either the old or new curricula.

This development is troubling because the reform agendas typically are coupled with more demanding, time-consuming, and complex performance expectations that require paying careful attention to a smaller number of strategic topics. Adding more topics will not help.

The impact of science reform recommendations remains untested as yet. Reform documents themselves often emerge from compromise among professionals, and this compromise may prevent them from stating a single vision. Even when a reasonably coherent voice emerges for reform—for example, the NCTM *Standards* in math education and the National Research Council's *National Science Education Standards*—our organizational context causes it to be heard as simply one more voice in a "babel" of competing voices. This "babel" becomes so overwhelming that it is hard for official actors to separate "signal" from "noise" or to prioritize the voices to which they will listen. In such a systemic context, splintered visions are likely to remain splintered.

The Need for Time

The lack of success that reform measures have had to date does not imply that they have been futile. Rather, they imply that reform may take considerable time.

Slow progress is certainly no reflection on the quality or power of mathematics and science reform efforts that have yet to be as effectual as their supporters wish in this climate. Certainly, it would be drastically wrong to conclude, based on these "early returns," that these reforms have failed. Rather, it seems more appropriate to be amazed at their current successes.

WHO ARE OUR CURRICULAR PEERS?

If we take seriously that the proportions of curricula, as set forth in state guidelines and textbooks, set bounds on what is broadly achieved by those taught, we should identify those countries that set similar bounds to their students' achievement.

In grade-eight mathematics, the U.S. composite curriculum as represented by textbooks is most like those of Australia, New Zealand, Canada, Italy, Belgium (French language system), Thailand, Norway, Hong Kong, Ireland, and Iceland.

In grade-eight science, our curriculum is most like that of New Zealand, Iceland, Greece, Bulgaria and the Peoples' Republic of China.

Are These the Peers We Want?

While the curriculum of any country is interesting and has some important features, we must ask if these are the countries with whom we are and will be trying to compete.

As a nation we desire to empower and inform our citizenry comparably as well as to effectively compete economically with other developed countries. We want attainments similar to the European Union, to the APAC countries (especially Japan and the "young tigers" of Korea, Singapore, etc.), and, most definitely, with the other G-7 countries.

When we find ourselves most similar to countries other than those with whom we seek to be peers, we have reason for deep concern. In matters of what is basic in teaching children mathematics and science, we are not peers with the composite of other TIMSS countries. We as a nation must be concerned.

What Is Necessary for Reform to Succeed?

The U.S. vision of mathematics and science is splintered. We are not where we want to be. We must change. But the required change is fundamental and deeply structural. There are no single answers or instant solutions.

Most nations do not share similarly splintered visions in mathematics and science education. Theirs are more coherent. While central guiding visions do not alone guarantee student achievement, they contribute to optimal attainments. These shared visions are insufficient to ensure desired achievements, but they seem necessary starting points.

The United States has a decentralized educational system in which the component organizations do not always work towards common goals, nor do they always aim at producing important combined results. Formal mechanisms of coordination—either by regulation or rewards for selected behaviors—have proven politically sensitive and are in limited use. Given such a culture of education, how can a focused vision be achieved? Several principles would seem to be at work:

Effective Reform Will Necessarily Be Systemic

Information- and motivation-based reforms and improvement policies alone will not bring fundamental improvements. Any serious attempt at change in U.S. science and mathematics education must be deeply structural. The fundamental problem is not a conglomeration of individual problems. Any effective reform in this context will necessarily be systemic—affecting several parts at once.

Not every systemic reform automatically will address the core of our problems. Appropriate structural reform must pursue focused and meaningful goals. We may not be able to do everything and do any of it well. Instead, it appears we must make choices regarding which goals are more important and how many goals we can effectively pursue.

Effective Reform Must Respect Cultural Context

Whatever actions are taken must be appropriate to our educational federalism and our context of shared educational responsibility. When discussion suggests the need for more powerful and coherent guiding visions, they must be sought in processes that will achieve wide consensus necessary for change in our context.

A corollary is that we may learn from other countries but we cannot emulate their centrally administered changes. Any reform in the United States must seek visions that can achieve broad consensus.

Conclusion

The United States needs powerful mathematics and science education because they:

- Provide a strong basis for our democracy by helping create a literate and informed citizenry;
- Help each individual to grow, develop, reach his or her individual potential, and become more autonomous and empowered; and
- Provide a sound basis for continuing national prosperity in a competitive, information-driven, technological, and changing international arena.

Perhaps we do not need a central focus for our curricula and teaching. Perhaps the value of diversity outweighs the value of focus. Perhaps our de facto emphasis on breadth will prove more effective overall than other countries' strategies of focusing on strategic topics. That is a matter for further empirical evidence and public discussion.

Both conventional wisdom and a considerable body of research, however, suggest that focus and selection are needed in situations in which too much is included to be covered well. The impact of these unfocused curricula and textbooks in mathematics and science likely includes lower "yields" from mathematics and science education in the United States Focus would seem to be a necessary but not a sufficient condition for high student attainments.

What kinds of mathematics and science education do we, as a nation, want for our children? While this is a central question for public debate, it seems likely that we want educations that:

- Are more focused, especially on powerful, central ideas and capacities;
- Provide more depth in at least some areas, so that the content has a better chance to be meaningful, organized, linked firmly to children's other ideas, and to produce insight and intuition rather than rote performance; and
- Provide rigorous, powerful, and meaningful content that is likely to produce learning that lasts and not just learning that suffices for the demands of schooling.

Questions to Ask

The authors of this report do not represent any official or policymaking group. Our job has been to design relevant research, analyze its results carefully, and report them objectively. Because of who we are, we do not feel it appropriate to make specific recommendations. We can, however, at least ask questions—questions that our results lead us to believe important for those who do set policy.

Most of these questions are not original with us, although their form here has been influenced by the data we investigated. In fact, some efforts are currently underway to address these questions, including the National Science Foundation's State Systemic Initiatives and the recently convened executive committee of the National Governors' Association in conjunction with business leaders. Those efforts may include answers to several pressing questions raised by these findings:

- How can we focus our mathematics and science curricula and textbooks around an intellectually coherent vision?
- How can we raise expectations and demands on our students?
- How can we help our teachers to do the best they can in teaching mathematics and science to our students?
- How can we find a better model for curriculum and instruction?
- How can we develop a new vision of what is basic and important?

Certainly these are not the only questions that must be asked and answered on the way to the revolution or, if one prefers, to a fruitful evolution in mathematics and science education. We have not touched on whole domains of issues—for example, concerns for equity in educational opportunity—because we did not want a report on the "splintered vision" of our children's education to be itself unfocused. Others must join in seeking answers to the questions raised here and the others we did not raise. Our data can help.

Presently, however, our story is simple. The U.S. vision of mathematics and science education is splintered. We are not where we want to be. We must change.

Works Cited

[1] The first, *Characterizing Pedagogical Flow,* discusses curriculum data in mathematics and science along with classroom observations and teacher interviews in six TIMSS countries. The second and third, *Many Visions, Many Aims: A Cross-National Investigation of Curricular Intentions in School Mathematics* and *Many Visions, Many Aims: A Cross-National Investigation of Curricular Intentions in Science Education,* are reports that present data on the full set of almost 50 TIMSS countries.

[2] At that time the National Council of Teachers of Mathematics (NCTM) *Standards* (for mathematics education) had existed for only about three years. The American Association for the Advancement of Science's (AAAS) *Benchmarks* (for science and mathematics literacy) had been released only in preliminary form. The National Academy of Science's National Research Council's *Science Education Standards* had yet to be fully formulated or released. Therefore this report cannot offer any conclusions about these reforms.

[3] Because the U.S. does not have a national curriculum, we aggregated states to find a representative average.

ANNOTATED BIBLIOGRAPHY FOR *GUIDEBOOK TO EXAMINE SCHOOL CURRICULA*

Anderson, C.W. "Strategic Teaching in Science." In Marcia K. Pearshall, ed. *In Scope, Sequence, and Coordination of Secondary School Science, Volume II: Relevant Research.* Washington, DC: The National Science Teachers Association, 1992, pp. 221-236.

A discussion of strategic teaching in elementary science classrooms. Using a hypothetical teacher, Ms. Lane, the author notes the various difficulties she might face in teaching a unit on light and vision. The four problem areas identified are (1) definitions of strategic teaching, (2) course curriculum, (3) student learning, and (4) student instruction. The author elaborates on the difficulties faced in each area and examines possible teaching responses. A teaching strategy based on conceptual change learning was found to be the most effective. Recommendations for improving teachers' ability to utilize strategic thinking and conceptual change learning are offered.

Anderson, Ronald H. *Studies of Education Reform: Study of Curriculum Reform.* Washington, DC: U.S. Department of Education, 1996.

A study of curriculum reform in mathematics, science, and higher order thinking. The study examined emerging reform practices focusing on which ones worked; what incentives for change were effective; and which means of overcoming barriers to change were successful. Nine case studies were conducted at various sites where reform was in progress. Preparatory work, reform methods, and results are discussed.

Archbald, Douglas A., and Porter, Andrew C. "Curriculum Control and Teachers' Perceptions of Autonomy and Satisfaction." *Educational Evaluation and Policy Analysis,* 16(1), Spring 1994, pp. 21-39.

A study designed to determine the effects of centralized curriculum control on teachers' opinions. High school mathematics and social studies teachers from six urban school districts were asked to rate their control and autonomy in various contexts. The districts were divided by type into high, medium, and low levels of centralized curriculum control. Mean ratings were presented from teachers in all three levels of centralization. The four scales were (1) Policy and Teacher-Discretion Influences, (2) Teacher Control Over Classroom Content and Pedagogy, (3) Staff Involvement in Decision Making for Course Content, and (4) Teacher Empowerment. Results were discussed in terms of individual scale ratings, overall ratings, and comparisons between mathematics and social studies teachers.

Ball, D.L., and Cohen, D.K. "Reform by the Book: What Is—Or Might Be—The Role of Curriculum Materials in Teacher Learning and Instructional Reform?" *Educational Researcher,* Volume 25, December 1996, pp. 6-8.

A discussion of the impact of curriculum materials on classroom instruction. The article suggests that the design of curriculum materials is one of the oldest ways to influence classroom instruction. Reformers have often used instructional materials as a means to shape what students learn. This strategy is often unsuccessful for it undermines the professional work of teaching and severely limits local discretion over curriculum. Curriculum materials play an "uneven role" in teaching practice because: (1) curriculum developers and others often have failed to take account of the teacher; (2) a gap exists between curriculum developers' intentions for students and teachers' understanding of the material and their beliefs about what is important for students to learn; and (3) many educators do not follow textbooks, but instead make their own curriculum. Hostility to texts has inhibited careful consideration of the constructive role that curriculum might play. The authors suggest that curriculum materials could lead to improved practice if they were created with closer attention to processes of curriculum enactment.

Brophy, J., and Alleman, J. "Activities as Instructional Tools: A Framework for Analysis and Evaluation." *Educational Researcher*, Volume 20, May 1991, pp. 9-23.

A study designed to stimulate increased scholarly attention to the design, selection, and assessment of learning activities and scaffolding of student involvement in those activities. It is argued that research has focused much more on content selection and representation and on teacher-student discourse than on activities. A conceptual analysis and a set of principles are proposed as tools for designing, selecting, and evaluating learning activities. The principles were drawn from generic curriculum sources and thus, theoretically, are applicable to all school subjects. Five sets of principles are offered: (1) primary principles that must apply to individual activities; (2) secondary principles that may apply to individual activities; (3) principles that apply to sets of activities; (4) additional principles that are associated with particular philosophies; and (5) principles that apply to the teacher's implementation of activities. The suggested principles are intended to help students engage in actively processing curriculum content, developing personal ownership and appreciation of it, and applying it to their lives in and outside of school.

Eggebrecht, John; Dagenais, Raymond; Dosch, Don; Merczak, Norman J.; Park, Margaret N.; Styer, Susan C.; and Workman, David. "Reconnecting the Sciences." *Educational Leadership*, 53(8), May 1996.

A description and discussion of the Integrated Sciences program at the Illinois Mathematics and Science Academy. Designed to bring all science subjects together into one classroom, the program is a three-semester, double-period course offered as an alternative to standard core sequence science instruction. The program is constantly evolving and adopting new techniques of instruction. By integrating the varied subjects, the instructors hope to overcome the deficiencies of standard science education: transfer of basic scientific knowledge and transfer of scientific authority. According to the authors, the program must be assessed in five key areas: (1) the context of national standards; (2)

student performance in relation to those standards; (3) positive student attitudes toward science; (4) adequate preparation for advancement; and (5) overall improved learning habits. Results indicated a positive outcome in the first four areas, while the fifth was still being determined. The program has demonstrated its success and has led to real intellectual growth for both students and instructors.

Goertz, Margaret E.; Floden, Robert E.; and O'Day, Jennifer. *Studies of Education Reform: Systemic Reform.* Washington, DC: U.S. Department of Education, 1996.

A study of systemic reform in 12 schools. The study was designed to expand knowledge of state approaches to systemic reform, examine responses to reform policies, identify challenges at all levels to reforming education, study the capacity of the system to support reform, and provide guidance to policymakers at all levels as they design and implement reform policies. A discussion of relevant literature is included. Analysis was done in three areas: (1) challenges to implementing systemic reform; (2) teachers' practice and opportunities to learn; and (3) capacity building and systemic reform. Policy and research implications are also offered.

Khattri, Nidhi; Reeve, Alison L.; Kane, Michael B.; and Adamson, Rebecca J. *Studies of Education Reform: Assessment of Student Performance.* Washington, DC: Pelavin Research Institute, 1996.

A study of performance assessments from various educational authorities at 16 school sites. The main objectives of the study were to examine the key characteristics of performance assessments, the facilitators and barriers in assessment reform, and the impacts of performance assessments on teaching and learning. Results were discussed as general policy implications, policy implications if assessment reform is to be used to improve and inform instruction and curriculum, and policy implications if assessment reform is to be used for school and/or district accountability. A discussion of implications for future research is also included.

Porter, Andrew. "A Curriculum Out of Balance: The Case of Elementary School Mathematics." *Educational Researcher*, 18(5), June-July 1989, pp. 9-15.

A study to examine the content of elementary mathematics courses. Using teacher logs and interviews, the researchers determined that teachers overemphasized skill development while neglecting to develop adequate conceptual understanding and problem-solving abilities. They also found that the majority of topics were taught briefly with no expectation of in-depth understanding. The differences in content between grades were negligible and did not align with student progress. Individual teachers and schools varied enormously in the overall amount of time spent teaching mathematics. Recommendations for correction are offered.

Porter, Andrew. "The Uses and Misuses of Opportunity-to-Learn Standards." *Educational Researcher*, 24(1), January-February 1995, pp. 21-27.

A discussion of Opportunity-to-Learn (OTL) standards as defined by the Goals 2000: Educate America Act. Noting the complicated legislative and political atmosphere surrounding the law, the author speculates on possible uses and definitions for OTL standards. The author states that OTL standards are not appropriate as measures of school accountability, but rather as measures of school improvement. It is noted that the standards can be used to determine successful practices, process indicators, and reform progress and as a tool to diagnose poor performance. OTL standards should include first and foremost a basic standard of a safe and orderly environment. What is actually taught in schools; the quality of pedagogy used; and the applications and uses of instructional resources such as libraries, laboratories, and computers should also be included. Criteria suggestions are also offered for other standards. While Goals 2000 may not fulfill all expectations, OTL indicators can be extremely helpful in aiding school improvement.

Roth, Kathleen J. "Science Education: It's Not Enough to 'Do' or 'Relate.'" In Marcia K. Pearshall, ed. *In Scope, Sequence, and Coordination of Secondary School Science, Volume II: Relevant Research.* Washington, DC: The National Science Teachers Association, 1992, pp. 151-164.

A discussion and evaluation of elementary science education teaching perspectives. In addition to traditional textbook-based science teaching, the author compares and contrasts the three main reform movements in science education. Inquiry teaching emphasized process skills and actual scientific work. Science-Technology-Society teaching also promoted process skills, but regards the use of scientific knowledge as most important. Conceptual change teaching involved imparting conceptual understanding of science and the overall usefulness of scientific knowledge. The final perspective was found to be the strongest.

Schmidt, William H.; McKnight, Curtis C.; Raizen, Senta A. *A Splintered Vision: An Investigation of U.S. Science and Mathematics Education.* Boston, MA: Kluwer Academic Publishers, 1996.

A Splintered Vision discusses data from the analysis of 491 curriculum guides and 628 textbooks from around the world collected as part of TIMSS. It also presents detailed accompanying data on teacher practices in the United States, Japan, and Germany. The report documents and characterizes the state of U.S. mathematics and science curricula, textbooks, and teaching practices and places them in a cross-national context. The report's authors conclude that the lack of a single coherent vision of how to educate today's children produces unfocused curricula and textbooks that influence teachers to implement diffuse learning goals.

Smith, Edward L.; Blakeslee, Theron D.; and Anderson, Charles, W. "Teaching Strategies Associated with Conceptual Change Learning in Science." *Journal of Research in Science Teaching*, 30(2), 1993, pp. 111-126.

A study examining conceptual change learning strategies for science teaching and its relationship to student performance. Thirteen seventh-grade life science teachers were observed teaching three units: photosynthesis, cellular respiration, and matter cycling in ecosystems. The teachers were divided into three groups; each group received varying levels of conceptual change learning preparation in the form of workshops and/or course materials. Students were given both pretests and posttests. The results demonstrated that the use of these instructional materials increased conceptual change learning and resulted in better student performance on posttests. Workshops alone had little impact on either area. A combination of both strategies was associated with higher student performances on tests. The study demonstrates the effectiveness of conceptual change learning strategies; however, few of the teachers were successful in implementing the strategies without the course materials. A discussion of conceptual change theories is also included.

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A report on the U.S. fourth-grade TIMSS results. It summarizes the most important findings concerning U.S. achievement and schooling in international context.

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